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1. INTRODUCTION

1.1 Purpose

The purpose of this manual is to provide guidance, design standards and policy direction when runoff detention and retention systems are required for development in Pima County. This manual is a supplement to, and has the same regulatory authority as, the Pima County Floodplain Management Ordinance, Title 16 of the Pima County Code.

Since 1987, the Stormwater Detention/Retention Manual (Pima County Department of Transportation & Flood Control District and City of Tucson), has required runoff detention systems to:

1. Protect adjacent properties from adverse impacts,

2. Preserve watershed-scale peak discharge characteristics, and

3. Retain a portion of stormwater runoff on site for re-use and infiltration.

This manual will continue to require protection of adjacent properties and preservation of pre-developed peak discharges but will incorporate revisions that:

1. Require first-flush retention that may be located throughout the development. The retained volume may be used to meet part of the project's detention volume requirement.

2. Include sustainability principles and promote early, integrated site planning,

3. Specify acceptable methods of analysis,

4. Provide detailed design standards,

5. Address maintenance responsibilities and expectations,

6. Standardize report and plan content requirements.

7. Facilitate use of the manual by Floodplain Administrators in both incorporated and unincorporated areas of Pima County.

1.2 Ordinance Overview and Detention Requirements

The broad goals of the Floodplain Management Ordinance (the Ordinance) are to protect the public health, safety and general welfare of the citizens of Pima County and to protect the

natural character of our watercourses, water resources and environment. The Ordinance requires the design of all new development to include elements which protect the site from flood damage and which protect adjacent and downstream properties from adverse drainage impacts.

The Ordinance requirements in Chapter 16.48, RUNOFF DETENTION SYSTEMS, support the overall goals of the Ordinance by mandating that post-development runoff rates be reduced to pre-development rates. In Section 16.36.030, Grading, stormwater, and drainage improvement, the Ordinance stipulates that development plans and tentative plats demonstrate that improvements are compatible with the existing upstream and downstream drainage conditions and that any proposed grading and/or grade change will not have an adverse impact on surrounding properties. These sections of the Ordinance form the foundation for the requirements presented in this manual.

With a general requirement for no adverse impact as directed in Section 16.36.030, the standards also rely on the more specific requirements in Chapter 16.48, including:

1. Any new development will include some method of peak discharge or volume reduction of runoff. Detention facilities may be omitted from project design if a waiver of this requirement is granted by the Floodplain Administrator and a fee is paid to the jurisdiction. A fee may be paid to the jurisdiction in-lieu of construction of detention facilities when the parcel to be developed is less than one acre in size; is located within close proximity to a major watercourse; is of low residential density (less than 2 residences per acre) and maintains the natural drainage patterns; or when other engineering justification acceptable to the Floodplain Administrator can be demonstrated. A Detention Waiver Request form is available on the District website: http://rfcd.pima.gov//pdd/guidelines/pdfs/det_ret_waiver.pdf, and more information is provided in Chapter 8, Detention Waiver Request and Payment of In-Lieu Fee.

2. Watershed basins within Pima County have been designated as Critical Basins or Balanced Basins, as shown on the Critical and Balanced Basin Map available at: http://rfcd.pima.gov/rules/pdfs/critical_basins.pdf. Unless a Detention Waiver has been granted, new development located within a Balanced Basin must provide sufficient detention to reduce the post-developed 2-, 10- and 100-year peak discharge rates to the pre-developed rates. When a Detention Waiver has not been granted, new development located within a Critical Basin must provide sufficient detention to reduce the post-developed 2-, 10- and 100-year peak discharge rates to 90% of the pre-developed peak discharge rates. Locations of post-developed concentration points at the downstream property boundary must approximate the location of pre-developed concentration points at the downstream property boundary, and the balanced and critical basin criteria are applicable at all downstream concentration points.

1.3 Applicability

This manual applies to the planning and design of runoff detention and retention systems when required for private Development Plans and Subdivision Plats. These standards do not apply to regional or public detention basins. The District does not allow the use of detention or retention within individual residential parcels to meet or offset any part of the detention or retention requirements for a project site.

1.4 Conflicting Requirements and Requests To Provide Designs, Analyses Or Reporting Which Are Different From The Requirements Stated In This Manual

If any of the requirements in this manual conflict with one another, the Ordinance or other District policies; the more restrictive requirement shall apply.

Requests to provide designs, analyses or reporting which is different from the requirements stated in this manual shall be made in writing to the Floodplain Administrator a minimum of 20 working days prior to submittal. A response shall be provided in writing to the applicant making the request within 20 working days.

1.5 Low Impact Development Practices

This manual introduces the use of Low Impact Development (LID) practices. LID practices model the natural environment with design elements which manage runoff and water use using uniformly-distributed small-scale controls. One goal of LID practices is to mimic a site's pre-development hydrology using methods that effectively capture, detain, infiltrate and evaporate runoff close to its source.

Two components of LID practices are site planning and hydrologic analysis. Traditionally, site development has allowed runoff to be conveyed quickly to a central point, such as a constructed channel or detention basin. This type of development is essentially devoid of natural features, and the result is an increase in runoff volume and peak discharge and an associated decrease in runoff travel time. In contrast, site development using LID practices contains features found in natural watersheds which can increase post-development travel time above that expected with traditional constructed conveyances, while reducing both peak discharge rate and runoff volume.

The use of LID practices accomplishes multiple goals including addressing State and Federal regulations requiring jurisdictions to reduce the contribution of pollutants from urbanized areas to our watercourses and providing a mechanism to direct runoff to landscape, bufferyards, and riparian areas in a way that also provides some flood control benefit.

Site design which incorporates LID concepts will include elements such as catchments immediately downstream of impervious surfaces and grading and interconnected curvilinear flow paths which reduce the velocity of surface flow. An example of a site design incorporating LID concepts is the Lester Street site at the University of Arizona and is illustrated in Figure 1.1.

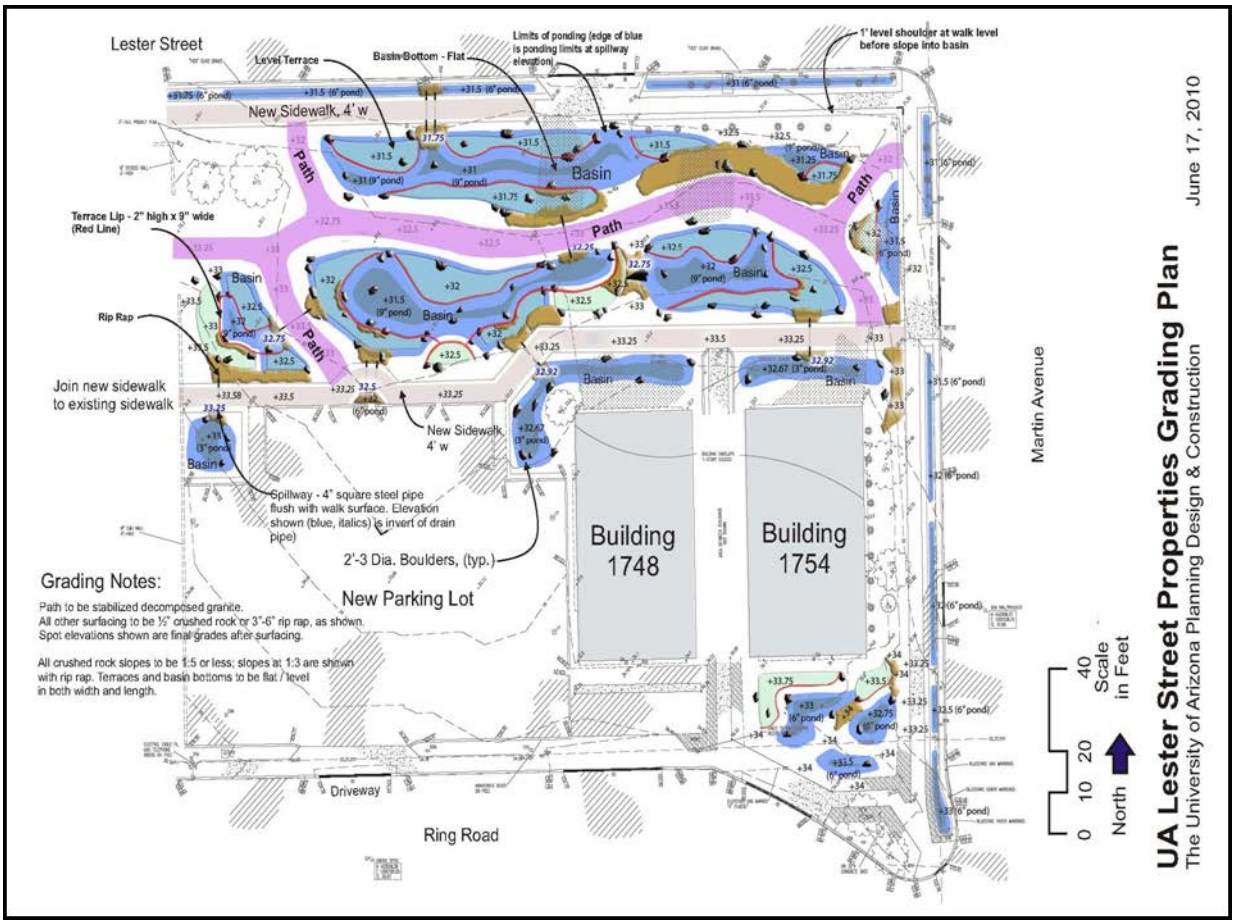


Figure 1.1 An Example of LID Site Design
(University of Arizona, Department of Planning, Design & Construction).

In this example design, runoff from roofs and parking areas is directed to a series of shallow basins which are interconnected by pipes or berm spillways, reducing the volume and rate of flow at the downstream boundary of the project.

Landscaping creates aesthetically pleasing runoff paths and increases evapotranspiration. The landscape concept for the Lester Street project is shown in Figure 1.2.

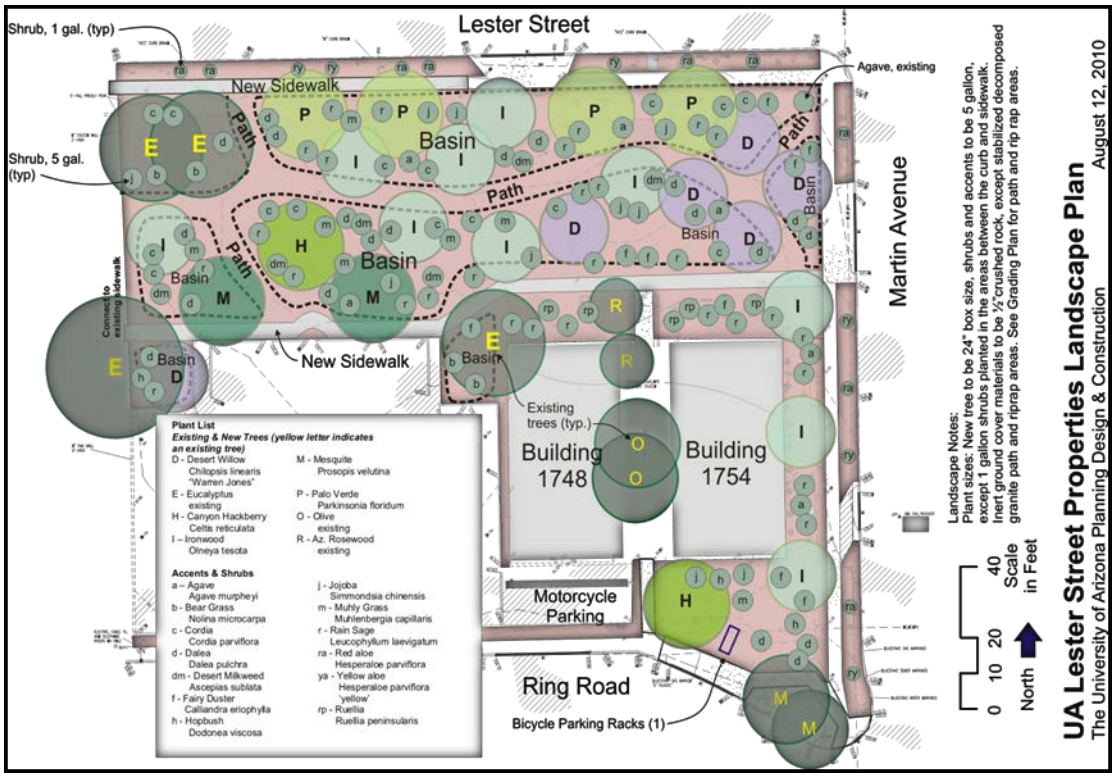


Figure 1.2 An Example LID Landscape Concept Plan
(University of Arizona, Department of Planning, Design & Construction).

The requirement, introduced with this manual revision, to retain first-flush retention can be satisfied by site designs which incorporate features similar to the example site design or by shallow retention within a detention basin.

First-flush retention is defined as the 0.5-inch runoff volume from all newly disturbed or impervious areas for new development or redevelopment as defined in Section 2.1. This requirement will not apply to those portions of the project site that are left undisturbed.

To incentivize the use of LID practices, the District will allow a reduction in the required volume of detention facilities in addition to mitigation of the first-flush retention requirements, when quantifiable flood control benefits can be measured.

Quantifiable flood control benefits can be demonstrated through reduction of the percentage of imperviousness and by the Stormwater Harvesting Peak Discharge Reduction procedure presented in Chapter 3 for the following practices:

1. Minimization of disturbed and impervious surfaces,

2. Protection and maintenance of riparian habitat and drainage patterns,

3. Use of stormwater harvesting in depressed earthen areas.

Use of any of these LID practices is optional, and the first-flush retention requirement can be satisfied in shallow retention within a detention basin.

Quantifiable flood control benefits may be able to be demonstrated by evaluating roughness and length of flow path for the following practices for projects with watershed times of concentration which exceed the minimum allowable by PC-Hydro:

4. Disconnection of impervious surfaces

5. Maximization of time of concentration through the use of swales, site design and increased lengths of flow paths, and

6. Use of conveyance systems which mimic natural conditions.

The following practice is encouraged by the District and can result in less excavation and disturbance although quantifying the flood control benefit is beyond the scope of this manual:

7. Decentralization of stormwater harvesting basins and detention basins

In order to facilitate the use of LID practices, the District encourages applicants to satisfy other requirements within LID practices. Other requirements which might be satisfied within LID practice site areas include landscaping, native plant, and riparian requirements. The location of mitigation areas may maximize the effect of proposed LID practices. Other regulatory requirements that could be met include open space set-aside, bufferyard, and park requirements.

Details and design standards for LID practices will be presented in Chapter 5.

1.6 Site Planning

Early review of the project site for opportunities to optimize the use of LID practices, to consider riparian habitat preservation and to reduce the site area devoted to deeply-excavated detention basins is encouraged by the District. While this manual provides standards and guidelines for designing, constructing and maintaining detention basins, it also promotes use of alternatives to excavated basins or a combination of detention basins and alternative practices to achieve required levels of stormwater detention and retention.

Site planning during rezoning processes and at the earliest stages of site review will allow for the most appropriate uses of LID practices, stormwater harvesting and riparian habitat and floodplain preservation. Site planners are encouraged to contact the Planning and Development Division of the District for consultation during preliminary site layout.

1.7 Design Standards

This manual presents the required design standards for detention basins and LID practices. Approval of the use of design standards not in this manual shall be obtained in writing from the District prior to submittal of the detention analysis.

The District intends to review this manual periodically and to update the manual if appropriate. As new construction methods and materials, environmental regulations and sustainable development practices evolve, new design standards may be incorporated into the manual.

2 FIRST-FLUSH RUNOFF VOLUME REDUCTION

Capturing and retaining stormwater throughout the project site results in a reduction in the size of infrastructure required to convey runoff to a central area. Additionally, it provides permeable area which allows more runoff to infiltrate into the ground.

Stormwater retention is required to address water quality protection goals, to reduce downstream adverse impacts related to the increased frequency of runoff from development, and to mimic natural features which allow for the beneficial re-use of stormwater on site.

2.1 Applicability of First-flush Retention And First-flush Runoff Volume Calculation

The first-flush volume of runoff is the 0.5-inch volume of stormwater that is expected to discharge from impervious and disturbed areas. The 0.5-inch rainfall event is the 85th percentile storm event, discussed in Appendix H. New development shall provide the retention volume necessary to retain the first-flush volume of runoff from impervious and disturbed areas as determined below:

1. When new development is proposed on vacant land, all proposed impervious and disturbed areas shall be used to determine the required first-flush volume of runoff.
2. When expansion of existing development occurs, the first-flush volume of runoff shall be calculated using:
    a. The total impervious and disturbed areas of the entire site, when more than 10,000 square feet of new development are proposed.
    b. Only the impervious and disturbed area associated with the proposed expansion, when between 2,000 and 10,000 square feet of new development are proposed. Expansion area is cumulative over the life of the project.
    c. First-flush retention is not required when an expansion of less than 2,000 square feet is proposed. The 2,000-square-foot threshold is cumulative.
3. A change of use of a property that does not increase impervious surfaces or disturbed area does not require first-flush retention.
4. Where known drainage problems have been documented by the Regional Flood Control District, mitigation through retention may be required for sites which would otherwise not be required to provide first-flush volume.

2.2 First-flush Retention Volume Calculation

The first-flush retention volumes required by this Section were determined using the SCS Curve Number method with a 0.5-inch rainfall event (Table 2.1).

Appendix H presents supporting data for the use of the 0.5-inch standard.

The first-flush retention volumes were found as the difference in runoff volume for post-developed and pre-developed conditions for a 0.5 inch rainfall event. For pre-developed conditions, NRCS Hydrologic Group B soils were assumed for Riparian areas and NRCS Hydrologic Group C soils were assumed for Non-Riparian areas.

For post-developed conditions, impervious areas replacing mapped riparian areas were represented as 0.5 inches of runoff, and other impervious areas were represented as the runoff found from using an NRCS Curve Number of 99. Disturbed areas were assumed to be D soils under post-developed conditions.

The first-flush retention volume shall be calculated according to the following:

1. The first-flush retention volume requirement shall be calculated separately for the impervious and disturbed areas of each watershed associated with flows that exit a project site. The calculation for the required first-flush retention volume shall be in accordance with Table 2.1, unless site-specific testing supports use of alternate values.

Table 2.1
First-flush Volume Required for Each Acre of Impervious or Disturbed Area by Type of Area Made Impervious or Disturbed

	Lower Permeability Area	Mapped Riparian Area or Other Higher Permeability Area
Applicable Impervious Area	1440 ft^3/ac	1815 ft^3/ac
Additional Disturbed Area	140 ft^3/ac	245 ft^3/ac

2. Within each watershed, retention areas that are used to meet the first-flush retention requirement shall be located downstream of an impervious area.
3. The total first-flush retention volume provided in each watershed shall satisfy the first-flush retention requirement for that watershed.
4. Retention volume in areas such as stormwater harvesting basins and retention within detention basins may be counted toward the required first-flush volume.
5. First-flush retention areas within stormwater harvesting basins may also be counted for reducing peak discharges as described in Section 3.3. First-flush retention volume within detention basins will be counted as volume within the detention routing procedures described in Section 3.4.
6. Disturbed areas include any areas of the project site which are graded, including detention basins and stormwater harvesting basins, in accordance with Section 2.1.

2.3 Site Planning and Preliminary Design Of Lid Practices To Minimize First-flush Volume

Minimizing a development's impervious footprint helps to preserve the natural hydrologic characteristics of a site. The objective of LID is to mitigate the potential for increased runoff due to disturbance. LID practices reduce runoff rates by minimizing the impervious and disturbed surface area and by promoting infiltration through preservation and enhancement of riparian areas and regulatory floodplains. Judicious layout of impervious areas can promote increased infiltration and reduced runoff.

LID practices which minimize impervious and disturbed areas, maximize the preservation/enhancement of riparian areas and regulatory floodplains, and maximize infiltration will reduce the required first-flush retention volume. By incorporating these practices in site design during initial planning, an applicant can minimize the amount of first-flush retention required.

During site planning, the following practices which can minimize the first-flush volume of runoff shall be considered.

2.3.1 Minimize Disturbed, Compacted and Connected Impervious Surfaces

Fundamental elements of low impact development are reducing a development's impervious footprint and limiting construction disturbance. By incorporating these elements at the site planning stage, an applicant has the opportunity to reduce the amount of required first-flush retention by minimizing the amount of impervious surface and by minimizing the grading/disturbance envelope. Table 2.2 summarizes acceptable practices to minimize imperviousness and disturbance.

Table 2.2 Acceptable Techniques to Minimize Disturbed, Compacted and Impervious Surfaces

Phase	Techniques
Planning	• Consolidate buildings and other impervious areas. • Minimize developed footprint. • Locate impervious surfaces on the site's least permeable soils or previously disturbed areas. • Minimize use of fill and avoid compacting soils.
Design	• Follow the site layout proposed during planning. • Delineate grading limits. • Delimit undisturbed areas which will be fenced during construction. • Maximize use of permeable paving materials.

In addition, disconnecting impervious surfaces provides a greater opportunity for runoff to infiltrate into the ground. At the site planning stage, an applicant has the opportunity to establish flow paths that avoid impervious areas and infiltrate runoff in permeable areas.

2.3.2 Protect/Enhance Riparian Habitat and Regulatory Floodplains and Other High Permeability Areas

Riparian habitat areas and regulatory floodplains are frequently areas where infiltration rates are higher, where runoff occurs more frequently and at greater rates, and where natural flow paths have been established historically. Disturbance of these areas often causes the greatest impact to the hydrology of a project site. Avoidance of riparian areas and regulatory floodplains retains the site's natural drainage pattern, allows for flow attenuation and additional infiltration due to increased roughness, and provides additional buffer from the impacts of a development on a watercourse. Acceptable techniques for protecting riparian areas and regulatory floodplains are summarized in Table 2.3.

Table 2.3 Acceptable Techniques to Protect/Enhance Regulated Riparian Habitat and Regulatory Floodplains

Phase	Techniques
Planning	• Avoid regulated riparian habitat and regulatory floodplains. • Identify available planting sites adjacent to regulated riparian habitat and regulatory floodplains. • Identify regulated riparian habitat where vegetation has been degraded and propose appropriate plantings.
Design	• Follow the site layout proposed during planning. • Provide limits of regulated riparian habitat and regulatory floodplains. • Delimit avoidance areas and enhanced planting sites. • Avoid channelizing or bank protecting within regulatory floodplains. • Restore degraded stream banks.

At the site planning stage, protection of the regulated riparian habitat and regulatory floodplains will reduce the required first-flush retention requirements, provide roughness to attenuate flows, and reduce or negate the requirement for riparian habitat mitigation. In addition, retention basins could be located immediately adjacent to existing riparian habitat in order to enhance this environment by creating a buffer between the developed and riparian areas and by providing supplemental irrigation through stormwater harvesting.

2.4 Use of LID Practices to Mitigate the First-flush Retention Requirement

The required first-flush retention volume shall be calculated for the impervious and disturbed areas of each on-site watershed using the first-flush retention volumes in Section 2.2. The total retention volume in each watershed must equal or exceed the required first-flush retention volume emanating from the impervious and disturbed areas within the watershed. Retention areas that are counted towards the first-flush requirement must be located downstream of an impervious or disturbed area.

For residential projects, stormwater or rainwater harvesting facilities provided on individual lots shall not be counted toward the project's first-flush retention requirement.

The following LID practices can satisfy the first-flush retention requirement.

2.4.1 Stormwater Harvesting Basins

Stormwater Harvesting Basins are depressed earthen areas in native soils that are located and designed to collect and retain runoff from on-site impervious or disturbed areas, such as parking lots or rooftops, for irrigation of vegetation. If the volume of the runoff directed to a stormwater harvesting basin exceeds the capacity of the basin, an overflow shall be provided. All stormwater harvesting basins shall have an inlet, but may or may not have an overflow, with the elevation of the overflow controlling how much water is collected and retained. The discharge rate from a water harvesting basin shall not exceed the capacity of downstream infrastructure or exceed the balanced or critical basin discharge level.

If the basin is sloped, the depressed area may contain internal berms to pond water in multiple cells with planting areas on the upstream side of the berm.

2.4.2 Roadside Stormwater Harvesting Basins

Roadside basins in native soils collect and retain runoff from impervious areas such as roadways or parking lots. Roadside basins should be located in appropriate areas after considering other factors such as driveway and sidewalk locations, utility locations, site visibility triangles, and catchment area. They may be located either in medians or on the developed side. Safety of pedestrians and vehicles shall be considered when locating roadside basins.

When roadside basins are proposed, they shall not be located at a roadway low point to assure flow conveyance within the roadway once the basin in full. Roadside basins require an inlet, but an outlet is not required because flow will follow the roadway slope rather than flowing into a basin which is at full depth. As shown in Figure 5.2, the design water surface elevation in the basin is set at or above the water surface elevation within the curbed roadway section.

2.4.3 Non-contributing Area Basins

Non-contributing Area Basins are stormwater harvesting basins designed to retain the 100-year stormwater volume which falls on the basin or on the basin and on the upstream adjacent drainage area as described in Section 2.4.3.

The bottom of a Non-contributing Area Basin may be flat and shall be designed for uniform ponding over the permeable bottom.

2.4.3.1 Types of Non-Contributing Area Basins

Non-contributing Area Basins may be of two types. Type 1 is designed to collect only the stormwater which falls on it, with no contribution from upstream areas. An example of this type of Non-contributing Area Basin is a landscape bufferyard with no inflow from upstream drainage areas. This type of Non-contributing Area Basin must be a minimum of 9” in depth to allow a minimum of 6” of water storage depth below the top, with a freeboard of 3”. The maximum depth for stormwater harvesting basins is 12”, allowing a maximum of 9” of water storage depth below the top, with a minimum 3” of freeboard. Designs for Non-contributing Area Basins with no inflow from adjacent areas shall comply with this maximum depth.

When this type of basin is proposed and designed to the required depth, the area of the basin is not included in any peak discharge calculations.

A Type 2 Non-Contributing Area Basin is located at a low point of a project site, such as within a paved or disturbed area of the site. When this type of Non-contributing Area Basin is proposed, the ratio of the immediately upstream drainage area to the pervious basin bottom area must not exceed 2:1. This type of basin shall be a minimum of 12” in depth, and a freeboard of 6” from the top of the basin to the top of the adjacent drainage area shall be provided. The maximum depth of the basin shall be 15” to allow for a maximum water storage depth of 9” and a minimum freeboard depth of 6”. The 12” maximum depth of stormwater harvesting basins is exceeded for this type of basin to provide an additional factor of safety for adjacent vehicular or pedestrian areas.

A Type 2 Non-contributing Area Basin meeting the above criteria and the area draining to it are not included in any peak discharge calculations.

2.4.4 Bioretention Basins

Bioretention is the practice of constructing a depressed area specifically to capture and infiltrate water using a constructed soil medium planted with vegetation. Bioretention basins may be used in the same location as stormwater harvesting basins or roadside basins, but contain a soil medium that encourages infiltration, soil moisture storage and plant growth. Bioretention basins may include perforated drainage pipe risers and subsurface drains to collect stormwater and move it to the subsurface. Bioretention basins enhance infiltration characteristics, which mean that the same surface planting area may collect more water, or the areal extent of roadside and stormwater harvesting basins may be reduced.

The volume captured by a bioretention feature includes both the surface capture volume and the void space (assumed to be 40%) of the engineered medium.

When bioretention is used, the inlet shall have a sediment trap to capture sediment and organic compounds that may reduce infiltration.

2.4.5 Retention within Detention Basins

A detention basin can also be designed to retain stormwater, and the volume of the retention within the detention basin can be used to meet the first-flush retention requirement.

Detention basins with uniform side slopes and no terraces may incorporate retention for a maximum depth of up to 9” below the lowest outlet elevation. The volume provided below the outlet can be counted as retention volume.

Terraces may be proposed within a detention basin in order to meet riparian habitat or native plant requirements. Chapter 5 provides standards for retention within detention basins.

3 PEAK DISCHARGE RATE REDUCTION

3.1 Peak Discharge Rate Reduction Requirements

The required reduction of post-developed 2-, 10- and 100-year peak discharge rates depends on whether the project site is located in a Balanced or Critical Basin.

- Within a Balanced Basin, post-developed peak discharge rates shall not exceed pre-developed peak discharge rates at the project boundary.
- Within a Critical Basin, post-developed peak discharge rates shall not exceed 90% of pre-developed peak discharge rates at the project boundary.

A Critical Basin map is available at: http://rfcd.pima.gov/rules/pdfs/critical_basins.pdf. All areas of Pima County which are not designated as being located within a Critical Basin are designated as being located within a Balanced Basin.

3.2 Peak Discharge Rate Determination

3.2.1 Pre-Developed Conditions

The pre-developed conditions peak discharge rates for each return period(Q_{pre-rp}) shall be established using the modeling methods described in the District's Technical Policy, TECH-015, *Acceptable Methods for Determining Peak Discharges,* and Technical Policy, TECH-018, *Acceptable Model Parameterization for Determining Peak Discharges*, and any other technical policies developed to assist with model parameterization. The District's Technical Policies are available at: http://rfcd.pima.gov/rules/#techpolicies.

3.2.2 Post-Developed Conditions

Post-developed conditions peak discharge rates for each return period ($Q_{post-rp}$) shall be established using the same methods as for pre-developed conditions.

3.3 Peak Discharge Rate Reduction by Stormwater Harvesting Basins

The optional use of stormwater harvesting basins throughout a project site can reduce the size of downstream detention basins. Distributing stormwater retention throughout the site reduces the volume of runoff flowing to a detention basin or other conveyance downstream and may increase the time of concentration.

Where stormwater harvesting basins are proposed, the following method, or other acceptable methods on a case-by-case basis, shall be used to quantify the peak rate reduction for each return period (example calculations are presented in Appendix F).

1. Calculate the post-development runoff volumes ($V_{post-rp}$) and peak discharge rates ($Q_{post-rp}$) for the 2, 10, and 100 year events (e.g $V_{post-2}, V_{post-10}, V_{post-100}$) for each watershed. Runoff volume shall be obtained from the following equation:

$$\textit{Equation 3.1} \qquad V_{post-rp} = \frac{C_{w-rp} P_{1-rp} A}{12}$$

Where:

$V_{post-rp}$	=	runoff volume for the return period, acre feet
C_{w-rp}	=	weighted runoff coefficient for the return period
P_{1-rp}	=	1-hour rainfall depth for the return period, inches
A	=	watershed area, acres

The solution to Equation 3.1 is the runoff volume reported in the PC-Hydro hydrograph report. The runoff volume total obtained from the PC-Hydro hydrograph is an approximation of the runoff volume obtained from Equation 3.1.

2. Calculate the volume of proposed stormwater harvesting basins (V_{bas}) for each post-developed watershed. (Retention volume within a detention basin is not included as stormwater harvesting basin volume because retention volume within a detention basin is used in detention routing calculations.)

3. Determine the area of the watershed that will flow to or through stormwater harvesting basins (A_s) and the total watershed area (A_t), and calculate the percent watershed area draining to stormwater harvesting (W_A) using the following equation:

$$\textit{Equation 3.2} \qquad W_A = \frac{A_s}{A_t}$$

Calculate the ratio (X_{rp}) of the basin volume (V_{bas}) to the post-development runoff volume $V_{post-rp}$ for each return period with the following equation:

Equation 3.3 $$X_{rp} = \frac{V_{bas}}{V_{post-rp}}$$

Or

$$X_{rp} = W_A$$

whichever is less.

For example, $X_2 = \frac{V_{bas}}{V_{post-2}}$

4. Stormwater Harvesting Factors (H_{rp}) for each return period are presented in the following table. See Appendix D for details on how the Stormwater Harvesting Factor was developed.

   For project submittals where stormwater harvesting basins are proposed, a spreadsheet which automatically returns the correct factor and calculates the peak discharge rate reduction due to stormwater harvesting basins is provided in Appendix E.

Table 3.1
Stormwater Harvesting Factors (H_{rp}) for Peak Discharge Rate Reduction Based on Volume Retained (X_{rp})

X_{rp}	H_{rp}	X_{rp}	H_{rp}	X_{rp}	H_{rp}
<0.10	0.000	0.40	0.390	0.71	0.711
0.10	0.009	0.41	0.402	0.72	0.720
0.11	0.023	0.42	0.413	0.73	0.729
0.12	0.037	0.43	0.425	0.74	0.738
0.13	0.051	0.44	0.436	0.75	0.747
0.14	0.064	0.45	0.447	0.76	0.756
0.15	0.078	0.46	0.458	0.77	0.765
0.16	0.091	0.47	0.469	0.78	0.773
0.17	0.104	0.48	0.480	0.79	0.782
0.18	0.118	0.49	0.491	0.80	0.790
0.19	0.131	0.50	0.502	0.81	0.799
0.20	0.144	0.51	0.513	0.82	0.807
0.21	0.157	0.52	0.523	0.83	0.816
0.22	0.170	0.53	0.534	0.84	0.824
0.23	0.183	0.54	0.544	0.85	0.832
0.24	0.196	0.55	0.555	0.86	0.840
0.25	0.208	0.56	0.565	0.87	0.848
0.26	0.221	0.57	0.575	0.88	0.856
0.27	0.234	0.58	0.586	0.89	0.864
0.28	0.246	0.59	0.596	0.90	0.871
0.29	0.259	0.60	0.606	0.91	0.879
0.30	0.271	0.61	0.616	0.92	0.887
0.31	0.283	0.62	0.626	0.93	0.894
0.32	0.295	0.63	0.635	0.94	0.902
0.33	0.308	0.64	0.645	0.95	0.909
0.34	0.320	0.65	0.655	0.96	0.916
0.35	0.332	0.66	0.664	0.97	0.923
0.36	0.343	0.67	0.674	0.98	0.930
0.37	0.355	0.68	0.683	0.99	0.938
0.38	0.367	0.69	0.693	≥1.00	0.945
0.39	0.379	0.70	0.702		

5. Use this information to determine the post-development peak discharge rate for each return period, Q_{swh-rp}, after accounting for the presence of the stormwater harvesting basins using the equation:

Equation 3.4 $$Q_{swh-rp} = Q_{post-rp}(1 - H_{rp})$$

If Q_{swh-rp} is equal to or less than Q_{pre-rp} (or 90% of Q_{pre-rp} for critical basins) for all three return periods, then additional detention is not required.

If Q_{swh-rp} is greater than Q_{pre-rp} (or 90% of Q_{pre-rp} for critical basins) for any return period, then additional detention is required.

In calculating the required amount of additional detention, an adjusted inflow hydrograph which accounts for the storage volume and attenuation provided by stormwater harvesting basins is incorporated in the detention basin routing methods of Section 3.4.

The Stormwater Harvesting Hydrograph Spreadsheet in Appendix E shall be used with the parameters determined here to convert the detention basin inflow hydrographs without stormwater harvesting into detention basin inflow hydrographs with stormwater harvesting. The stormwater harvesting hydrograph from a site with stormwater harvesting basins may be used as the inflow hydrograph to a detention basin or another location.

In addition to attenuating peak discharge rate for a given return period, Q_{swh-rp}, stormwater harvesting basins reduce the post-development runoff volume, V_{swh-rp}. The amount of volume reduction for a given return period can be estimated by Equation 3.5 when $V_{bas}/V_{post\text{-}rp} < W_A$ as:

Equation 3.5 $$V_{swh-rp} = V_{post-rp} - V_{bas}$$

Otherwise, $V_{swh\text{-}rp} = V_{post\text{-}rp}(1-W_A)$

Volume reductions can be calculated in the Stormwater Harvesting Hydrograph Spreadsheet.

3.4 Peak Discharge Rate Reduction by Detention Basins

Incorporation of LID practices and site layout practices can minimize detention basin volume. When optional LID practices are not included in site design or when LID practices do not reduce peak discharge rates to required levels, detention basins must be included in site design.

The following methods shall be used to determine the peak discharge rate reduction provided by the detention basins.

3.4.1 Methods to Calculate the Peak Discharge Rate Reduction by Detention Basins

The amount of peak discharge rate reduction provided by a detention basin shall be determined by the storage-indication method which calculates change in storage over a time step by the following relationship:

Equation 3.6 $$\frac{(I_{t+1} + I_t)}{2}\Delta t - \frac{(O_{t+1} + O_t)}{2}\Delta t = S_{t+1} - S_t$$

Where:

I_{t+1} = inflow at time t + 1
I_t = inflow at time t
O_{t+1} = outflow at time t + 1
O_t = outflow at time t
Δt = length of time step
S_{t+1} = storage volume at time t + 1
S_t = storage volume at time t

The average inflow over a time step minus the average outflow over a time step equals the change in storage volume during that time step.

Developing a basin design with sufficient storage volume and an outlet design with an appropriate storage-discharge relationship, results in an outflow hydrograph with the target peak discharge. The target discharge will be the pre-developed peak discharge for Balanced Basins or 90% of the pre-developed peak discharge for Critical Basins.

The District's PC-Route.xls spreadsheet is recommended for basin routing. Appendix I includes information about its development, instructions and an example. The spreadsheet is presented in Appendix J. HEC-HMS is also acceptable software for basin routing. Other programs in the public domain may be considered on a case-by-case basis. Permission to utilize software other than the District's spreadsheet or HEC-HMS must be obtained in writing from the District prior to submittal of the detention analysis.

The process of designing a basin and associated outlets is usually iterative. That is, an estimated volume and basin shape are assumed for the first iteration. The estimated basin volume may be obtained from the following equation:

$$Equation\ 3.7 \qquad V_s = \frac{C_w P_t A}{12}\left[1 - \frac{Q_o}{Q_i}\right]$$

Where:

V_s	=	estimate of required storage volume, in acre feet
C_w	=	weighted runoff coefficient reported by PC-Hydro for developed conditions
P_t	=	1-hour rainfall depth for the design storm under investigation (inches)
A	=	watershed area (acres)
Q_o	=	detention basin outflow (cfs)
Q_i	=	detention basin inflow (cfs)

Once an initial estimate of the storage volume is obtained, the size of outlet pipes and/or heights of weirs or other outlet types are assumed. A trial run gives results which may reach the target for all or none of the three design storms. By adjusting the volume of the basin or the design of the outlet, the designer can successively approximate the design needed to reach regulatory criteria for all three design storms.

First-flush retention volume, calculated by Table 2.1, when provided within a detention basin should be included in the detention routing calculations.

4 DETENTION BASIN DESIGN STANDARDS

The following design standards apply when detention basins are proposed. Deviation from these standards requires written approval of the Floodplain Administrator. Additional standards to address specific site conditions may apply. These standards apply to Detention Basins without retention. If retention is proposed within a Detention Basin, design shall follow the standards in Section 5.6.

Requirements for Drainage Report content are provided in Chapter 9, Drainage Report Content, and the required content for Development Plans and Plats is found in Chapter 10, Requirements for Plats, Development Plans. Required content for As-Builts is described in Chapter 11, Required Content for As-Built Certification and Plans. Typical details required on plans are provided in Appendix B.

4.1 Detention Basin General Requirements

1. Inspection and Maintenance Plans are required for all basins. The Inspection and Maintenance shall be reviewed and approved by the District prior to approval of the Tentative Plat or Development Plan. An example of a detention basin inspection and maintenance checklist can be found in Appendix C.

2. To allow performance of inspection and maintenance, basins shall be legally and physically accessible.

3. Upon completion of construction of all basins, an as-built certification of the basin shall be prepared and submitted to the District. The as-built certification shall be used by the responsible party when performing periodic inspections and when restoring the basin to design specifications, if required.

4. Any modification of a basin that would affect volume or performance requires a Floodplain Use Permit.

5. When detention basins are to be maintained by a private entity, such as a Homeowners Association, this responsibility shall be described in the association's Covenants, Conditions and Restrictions which shall refer to the Inspection and Maintenance Plan and as-built certification.

4.2 Detention Basin General Prohibitions

1. Although the use of stormwater and rainwater harvesting facilities on private residential lots is encouraged, any retention volume on private residential lots shall not be counted towards reducing the required detention volume for the project.

2. Counting rainwater harvesting cistern volume to reduce the required detention volume is prohibited.

3. On-line detention for regulatory flows is prohibited.

4.3 Detention Basin Location and Collection

4.3.1 Detention Basin Location and Collection Standards

1. Basins shall be located within the project boundary.

2. Basins shall be located a sufficient distance upstream of the project boundary to ensure that post-development flow depth, width and velocity approximate pre-developed flow conditions when flow exits the project boundary.

3. To allow maintenance access, a minimum 10-foot setback from basins and appurtenances, including basin outlets (but not including outlet protection) and outer toes of embankments, to the project boundary shall be provided. An example is shown in Figure 4.1.

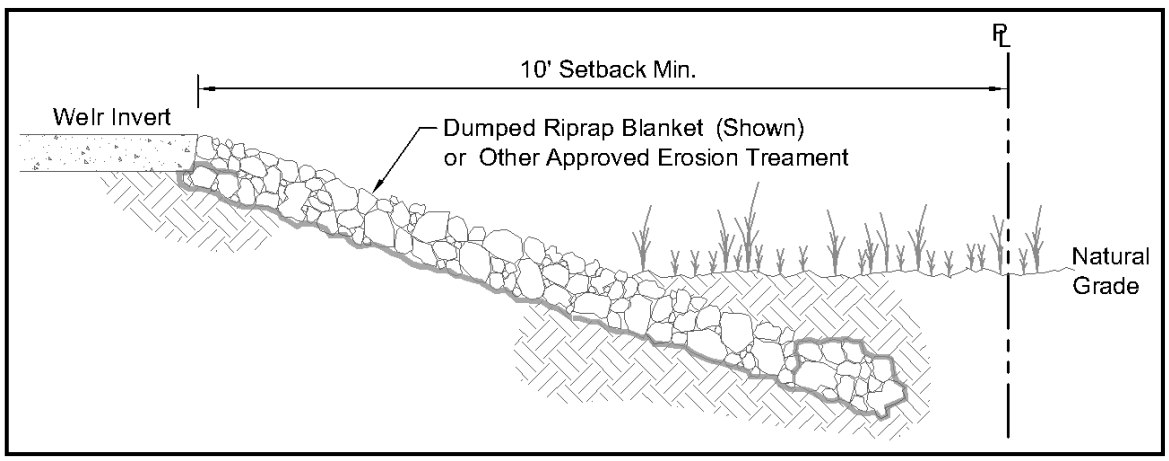


Figure 4.1 Minimum Setback from Property Line

4. In subdivisions, detention basins shall be located in Common Area for Drainage.

5. Basins shall be located to avoid the use of embankments, if possible.

6. When basins are located to accept flows from predominantly natural areas, sediment basins shall be required at the inlet. The configuration and volume of the sediment basin shall be determined by an engineer registered in the State of Arizona.

4.3.2 Detention Basin Location and Collection Maintenance Requirements

1. Basins shall be maintained to perform as designed for the life of the project and shall not be converted to a different use without a Floodplain Use Permit.

2. Inlet and outlet locations shall be maintained free of obstructions.

4.3.3 Detention Basin Location and Collection Prohibitions

1. Basins shall not be located within a regulatory floodplain, except when an entire project site is located within a regulatory sheet flooding area.

2. Inlets or outlets which direct flow to a sidewalk or other paved pedestrian pathway shall include a scupper or other conveyance to prevent sidewalk or pathway overtopping by the 10-year design discharge. Inlets or outlets shall not direct flow over a decomposed granite or other erodible pedestrian pathway.

3. Inlets or outlets shall not direct flow through a handicap accessible ramp or handicap parking space.

4. Post-development alterations that affect the function or design of drainage infrastructure are prohibited unless prior approval is obtained from the District. Alterations requiring approval include, but are not limited to, alteration of drainage structures, construction of new improvements and post-development site grading which increases flows to or causes flows to bypass the basin.

4.4 Detention Basin Depth and Freeboard

4.4.1 Detention Basin Depth and Freeboard Standards

1. Minimum freeboard shall be 6 inches within basins constructed below natural grade and 12 inches within basins designed with an embankment.

2. Freeboard is measured from the 100-year water surface elevation to the lowest top of the basin bank, as shown in Figure 4.2.

3. The water depth is measured from the lowest elevation on the basin floor to the top of the 100-year water surface elevation, as shown in Figure 4.2.

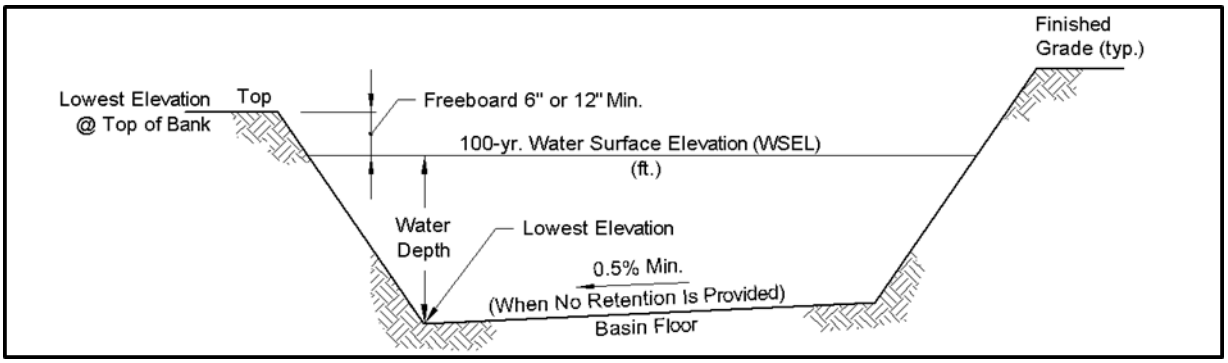


Figure 4.2 Basin Depth and Freeboard Requirements

4. Basins shall have a minimum of 1 sediment level measurement device, which can be incorporated into the weir or the side slope, or constructed as a separate stand-alone device. The device(s) shall be located where sediment is likely to accumulate.

5. Basins designed for 100-year water depths of greater than 2 feet and with side slopes steeper than 4:1 shall have a security barrier at all locations where side slopes are steeper than 4:1. Security barriers shall meet the requirements found in Section 4.11.

4.4.2 Detention Basin Depth and Freeboard Maintenance Requirements

1. The depth of the basin shall be inspected annually to ensure the design volume is maintained.

2. Design volume shall be restored when the depth of sediment exceeds 6” above the lowest bottom floor elevation shown on the basin as-built plans.

3. Slopes shall be maintained to the original design configuration.

4.4.3 Detention Basin Depth Prohibition

1. 100-year water depth shall not exceed 6 feet.

4.5 Storage Time

4.5.1 Storage Time Standards

1. The maximum storage time for a basin that intercepts runoff from a watershed up to 10 acres in size is 12 hours. The storage time is defined as the time required for ponding to be removed from the basin.

2. The maximum storage time for a basin that intercepts runoff from a watershed greater than 10 acres in size is 24 hours. The storage time is defined as the time required for ponding to be removed from the basin.

4.5.2 Storage Time Maintenance Requirements

1. Basin bottoms shall be inspected annually and after storm events for evidence of ponding lasting longer than the limits in Section 4.5.1.

2. If an inspection identifies evidence of ponding lasting longer than the limits in Section 4.5.1, the following maintenance shall be performed:
   a. Areas of ponding shall be graded to drain to the outlet,
   b. Compacted soil shall be scarified to promote infiltration,
   c. Basin outlets shall be maintained to function as designed, and
   d. Obstructions at the outlet shall be removed.

4.6 BASIN FLOOR

4.6.1 Basin Floor Standards

1. The basin floor shall be graded to a slope of 0.5% or steeper to provide positive drainage to the basin outlet, when no retention is provided, as illustrated in Figure 4.3.

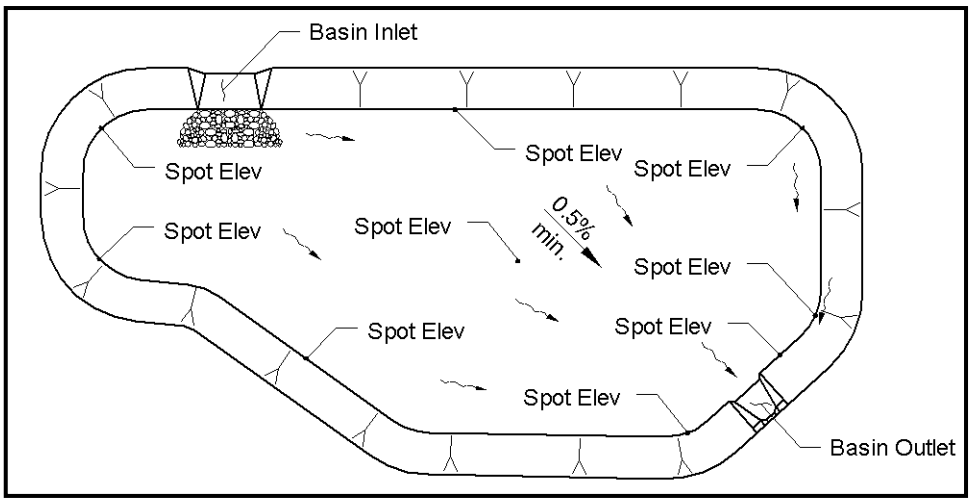


Figure 4.3 Basin Floor Minimum Slope for Positive Drainage

2. The basin floor may be hydroseeded. If hydroseeding is proposed, plant species used in the seed mix shall be selected from the Approved Plant List provided in Appendix B of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

3. Other types of vegetation shall comply with Section 4.19.

4.6.2 Basin Floor Maintenance Requirements

1. The basin floor shall be inspected annually and after storm events to ensure that positive drainage is maintained for basins that do not include retention volume.

2. Maintenance shall be performed when accumulated sediment and debris alter the design slope to the basin outlet.

3. Invasive non-native plants shall be removed. A list of the invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

4. Compacted soil shall be scarified to avoid areas of ponding and promote infiltration.

5. Soil with evidence of oil, grease or other chemicals shall be removed and disposed of properly.

6. Debris and trash shall be removed from the basin at least annually.

4.6.3 Basin Floor Prohibitions

1. The use of decomposed granite or rock less than 4 inches in diameter on the basin floor is prohibited.

2. Invasive non-native plants on the basin floor are prohibited.

4.7 Side Slopes

4.7.1 Side Slope Standards

1. Recommended side slope stabilization is presented in Table 4.1.

2. Side slopes with a horizontal-to-vertical ratio of 3:1 or greater shall be stabilized by hydroseed or other more durable stabilization stipulated in the geotechnical report. The minimum slope stabilization treatment shall be hydroseed.

3. Side slopes with horizontal-to-vertical ratios of less than 3:1 shall be stabilized according to Table 4.1, or as otherwise specified in the geotechnical report.

Table 4.1 Side Slope Stabilization

Side Slope	Stabilization Method
3:1 or flatter	Approved Hydroseed Dumped Riprap with Filter Fabric
no steeper than 2:1	Hand Placed Riprap with Filter Fabric Gabion Mattress
no steeper than 1.5:1	Articulated Revetment Units
no steeper than 1:1	Grouted Riprap Concrete Lining with Welded Wire Fabric Gabions
Vertical	Retaining Wall

The following standards apply to side slope treatments:

1. Dumped riprap shall have a D_{50} of at least 6 inches and be placed with a blanket thickness of 2 times the D_{50}.

2. Hand placed or dumped riprap shall consist of hard, durable angular stone. Gradation shall be provided as described in Table 4.2.

Table 4.2 Dumped or Hand Placed Riprap Gradation

Dumped/Hand Placed Riprap Gradation	
% Passing	Size
100 – 90	2.00 D_{50}
85 - 70	1.50 D_{50}
50 – 30	1.00 D_{50}
15 – 5	0.67 D_{50}
5 - 0	0.33 D_{50}

3. Unless grouted, rock riprap shall be underlain with filter fabric. The filter fabric shall be woven for a minimum of 2 feet into the upper end of the blanket and wrapped for a minimum of 2 feet around the riprap base of the blanket as illustrated in Figure 4.4.

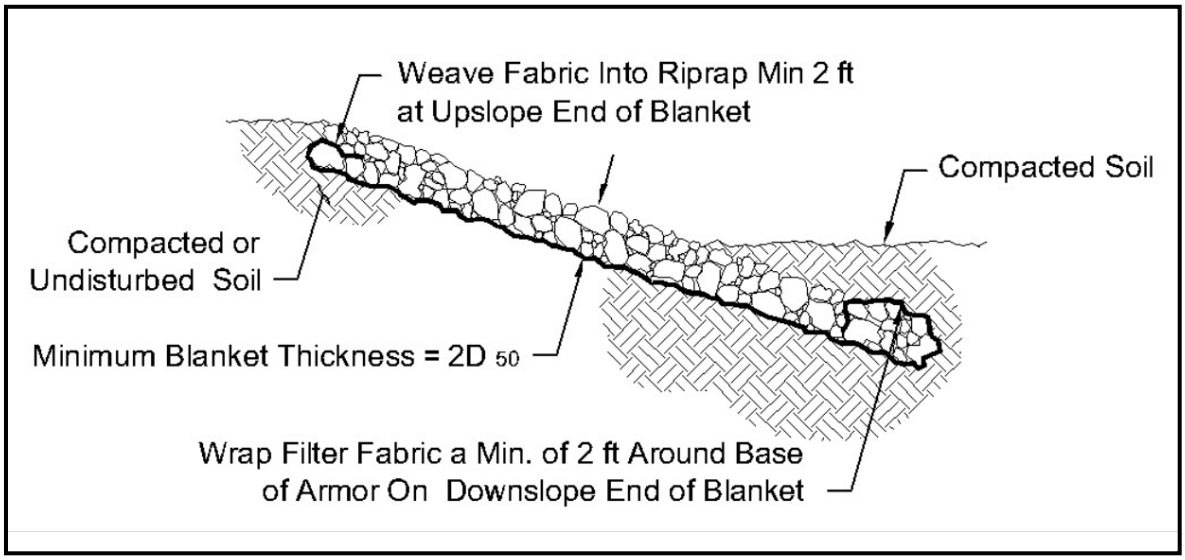


Figure 4.4 Riprap Blanket with Filter Fabric End Treatment

4. Grouted riprap shall be placed on a grout bed at least 6 inches thick. Stones shall be hard, durable and hand-embedded into the grout bed to a minimum depth of one-half the grout depth.

5. Vertical basin sides shall be designed as a retaining wall.

6. When a retaining wall is proposed as a basin side slope, stability design for the retaining wall shall be provided with the Development Plan or Tentative Plat. A detail, accompanied by a report clearly stating the assumptions about all soil parameters under saturated conditions, shall be provided and sealed by an engineer registered in the State of Arizona.

7. When hydroseed is used as slope treatment the seed mix shall have plant species from the Approved Plant List provided in Appendix B of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available at http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

4.7.2 Side Slope Maintenance Requirements

1. Inspections shall occur annually and after storm events to ensure that slope treatment has not been damaged by settling, vegetation, erosion, or other causes.

2. Should damage be observed, basin side slopes shall be restored to design specifications.

3. When slope treatment is dumped riprap, the treatment shall be repaired when foundation soil is lost or filter fabric is exposed.

4. Filter fabric that has migrated under the dumped rock riprap layer or has tears or holes shall be restored to design specifications.

5. Grouted riprap side slopes shall be restored to design specifications when foundation soil is lost.

6. Retaining walls shall be restored to design specifications when signs of tipping, clogged weep holes or soil subsidence are observed.

4.7.3 Side Slope Prohibitions

1. Free-standing walls are not allowed as a basin side.

2. Retaining walls greater than 4 feet measured from the bottom of the footing are not allowed as a basin side, unless prior approval is obtained from the District.

3. Riprap that consists of rock that is not hard and durable is not allowed.

4. Invasive non-native plants located on a basin side slope are not allowed. A list of the invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

4.8 Inlet Structures

4.8.1 Inlet Structure Standards

1. Inlets shall be placed immediately downstream of development to collect the increased stormwater runoff from post-developed conditions.

2. The capacity of an inlet structure shall be determined by methods provided in:
    a. *Drainage and Channel Design Standards for Local Drainage for Flood Plain Management within Pima County, Arizona,*
    b. The *City of Tucson Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*, or other methods accepted by the District.
    c. Other methods accepted by the District.

3. When flow crosses a sidewalk or other paved pedestrian pathway, a scupper or other conveyance to prohibit overtopping of the 10-year design discharge shall be used. Inlets shall not direct flow over a decomposed granite or other erodible pedestrian pathway.

4. When pipes are used as an inlet, the minimum size allowed is 12 inches.

5. Inlets shall have erosion protection with dimensions determined by the methods provided in the:
    a. *Drainage and Channel Design Standards for Local Drainage for Flood Plain Management within Pima County, Arizona*,
    b. *Federal Highway Administration, Hydraulic Engineer Circular No. 14; HEC-14*, or
    c. Other methods accepted by the District.

6. The erosion protection shall extend below the finished grade of the basin floor and/or side slope. The surface of the erosion protection shall be level with the finished grade as illustrated in Figure 4.5.

7. Unless grouted, rock riprap shall be underlain with filter fabric. The filter fabric shall be woven for a minimum of 2 feet into the upslope end of the blanket and wrapped for a minimum of 2 feet around the riprap base of the blanket on the down-slope end as shown in Figure 4.4.

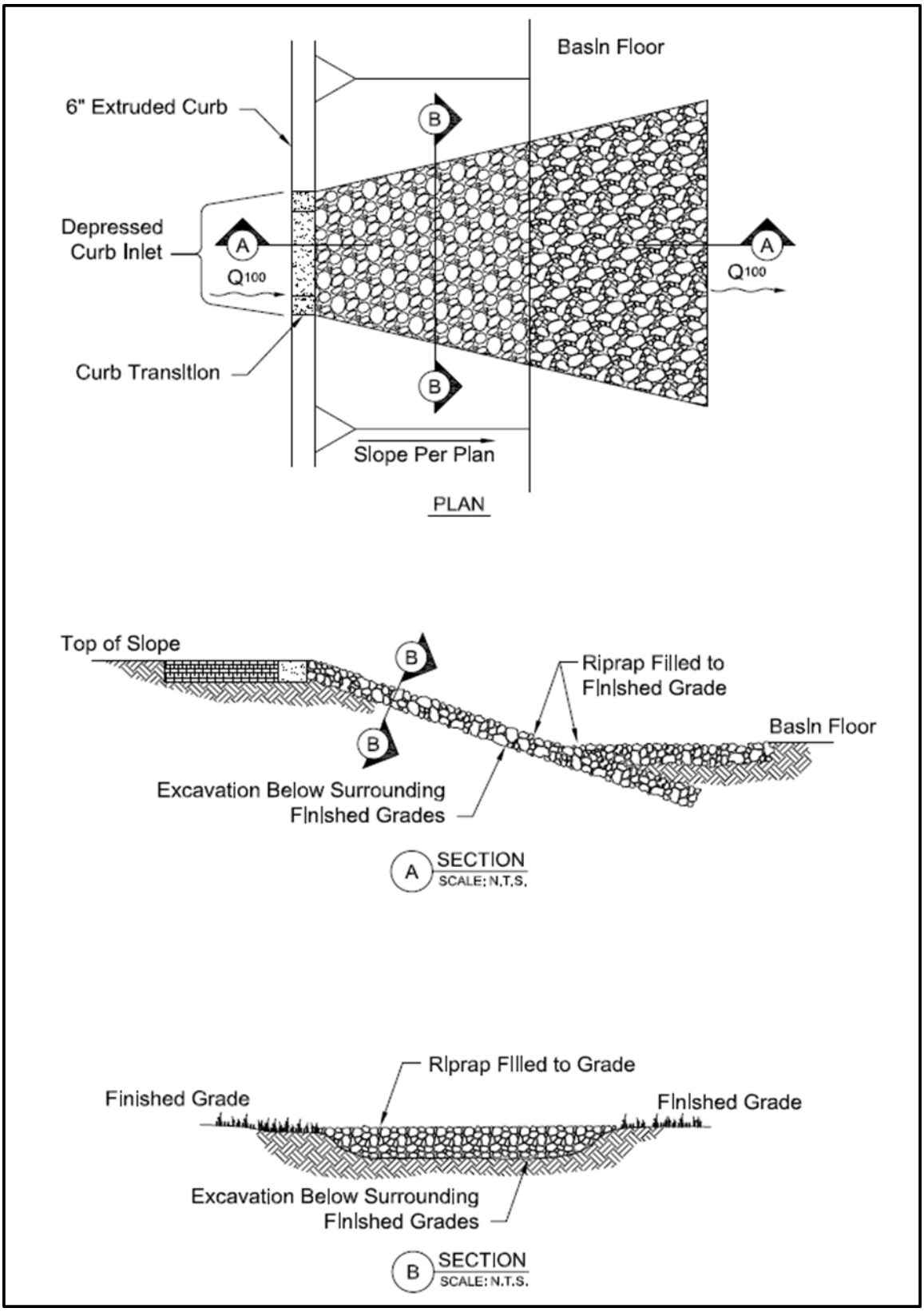


Figure 4.5 Erosion Protection below Finished Grade

Photo 4.1 shows a basin inlet in service which does not exhibit degradation of the basin slopes or floor near the inlet, indicating that an adequate riprap transition was provided. The standards in this manual attempt to provide guidance for designs which will remain well-maintained during the project life.

Photo 4.1 Basin Inlet with Riprap Protection

Photo 4.2 illustrates inadequate riprap placement resulting in erosion extending away from the basin inlet erosion protection.

Photo 4.2 Basin Inlet with Inadequate Transition Riprap Placement

Photo 4.3 shows an outlet structure with no erosion protection and the resulting erosion downstream. Photo 4.4 shows erosion protection downstream of an outlet structure which reduces erosion risk as required by these guidelines.

Photo 4.3 Erosion at a Basin Inlet Lacking Riprap Placement

Photo 4.4 Adequate Riprap Placement Prevents Erosion

4.8.2 Inlet Structure Maintenance Requirements

1. Inspections shall occur annually and after storm events to ensure the inlet is free of obstructions and not damaged.

2. Should obstructions or damage be observed, inlets shall be restored to design specifications.

4.8.3 Inlet Structure Prohibitions

1. Inlets shall not direct flow through a handicap accessible ramp or handicap parking space.

2. Water exceeding 12 inches in depth at an inlet located in a vehicular use area is prohibited.

4.9 Outlet Structures

4.9.1 Outlet Structure Standards

1. Outlets shall be designed to ensure that flows exiting the project boundary are compatible with the existing downstream drainage conditions and will not have an adverse impact on surrounding properties.

2. Outlets shall be designed to release flow from the basin at rates that do not exceed the 2-, 10- and 100-year pre-development peak discharge rates as determined by the methods specified in Chapter 3 of this manual. Examples of outlet structures are shown in Figures 4.6 and 4.7 and Photo 4.5.

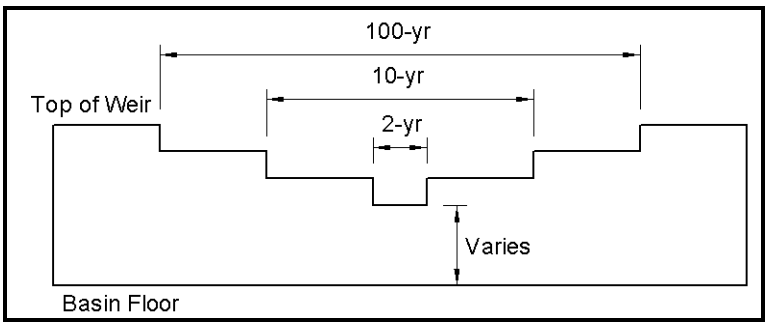
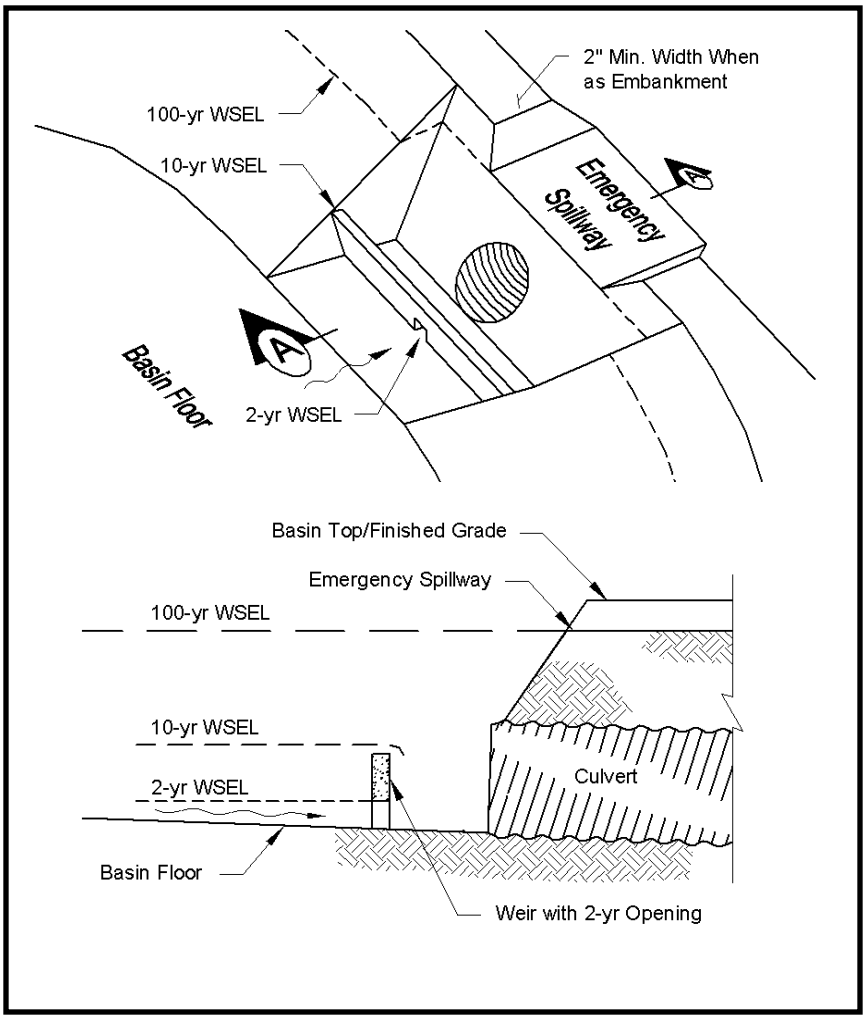


Figure 4.6 Multi-Level Weir Outlet for the 2-, 10-, and 100-year Storm



Cross Section A-A

Figure 4.7 Combination Weir – Culvert Outlet

Photo 4.5 Combination Weir Box

3. The capacity of outlet structures shall be determined using methods provided in:
    a. *Drainage and Channel Design Standards for Local Drainage for Flood Plain Management within Pima County, Arizona,*
    b. The *City of Tucson Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*, or
    c. Other methods accepted by the District.

4. Outlets which direct flow to a sidewalk or other paved pedestrian pathway shall include a scupper or other conveyance to prevent sidewalk or pathway overtopping by the 10-year design discharge. Outlets shall not direct flow over a decomposed granite or other erodible pedestrian pathway.

5. Outlets shall have erosion protection with dimensions determined by the methods provided in:
    a. *Drainage and Channel Design Standards for Local Drainage for Flood Plain Management within Pima County, Arizona*,
    b. *Federal Highway Administration, Hydraulic Engineer Circular No. 14; HEC-14, or*
    c. Other methods accepted by the District.

6. The erosion protection shall be placed beneath the finished grade of the downstream side of the outlet. Soil shall be excavated and removed beneath the erosion protection so that the top of the erosion protection is coincident with the finished grade as shown in Figure 4.5.

7. Unless grouted, rock riprap shall be underlain with filter fabric. The filter fabric shall be woven a minimum of 2 feet into the upslope end of the blanket and wrapped for a minimum of 2 feet around the riprap base of the blanket on the down-slope end as shown in Figure 4.4.

4.9.2 Outlet Structure Maintenance Requirements

1. Inspections shall occur annually and after storm events to ensure the outlet and all components are free of obstructions and not damaged.

2. Should obstructions or damage be observed, outlets shall be restored to design specifications.

4.9.3 Outlet Structure Prohibition

1. Outlets shall not direct flow to a handicap accessible ramp or handicap parking space.

4.10 Embankments

An embankment, for the purposes of this manual, is a side of a detention basin constructed above natural grade. A typical embankment is illustrated in Photo 4.6.

Photo 4.6 Embankment in a Residential Subdivision Basin

4.10.1 Embankment Standards

1. When site constraints prevent a basin from being constructed entirely below grade, an embankment is allowed. Site constraints include topography, existing infrastructure and conflicting code requirements.

2. When an embankment is proposed, the applicant shall include a discussion in the Drainage Report of conditions downstream of the embankment and the possible effect on public safety and property in the event of embankment failure.

3. Embankments shall have a top width of at least 5 feet.

4. Embankments shall provide at least 1 foot of freeboard above the 100-year water surface elevation in the basin.

5. Embankments shall be compacted to at least 95% of Standard Proctor density.

6. Removal of a minimum of 6 inches of in-situ soil beneath the embankment base prior to embankment construction shall be specified.

7. When an outlet is placed within an embankment, an anti-seep collar, adhering to the specifications shown in Figure 4.8, shall be provided. The diaphragm may be metal, concrete or geotextile.

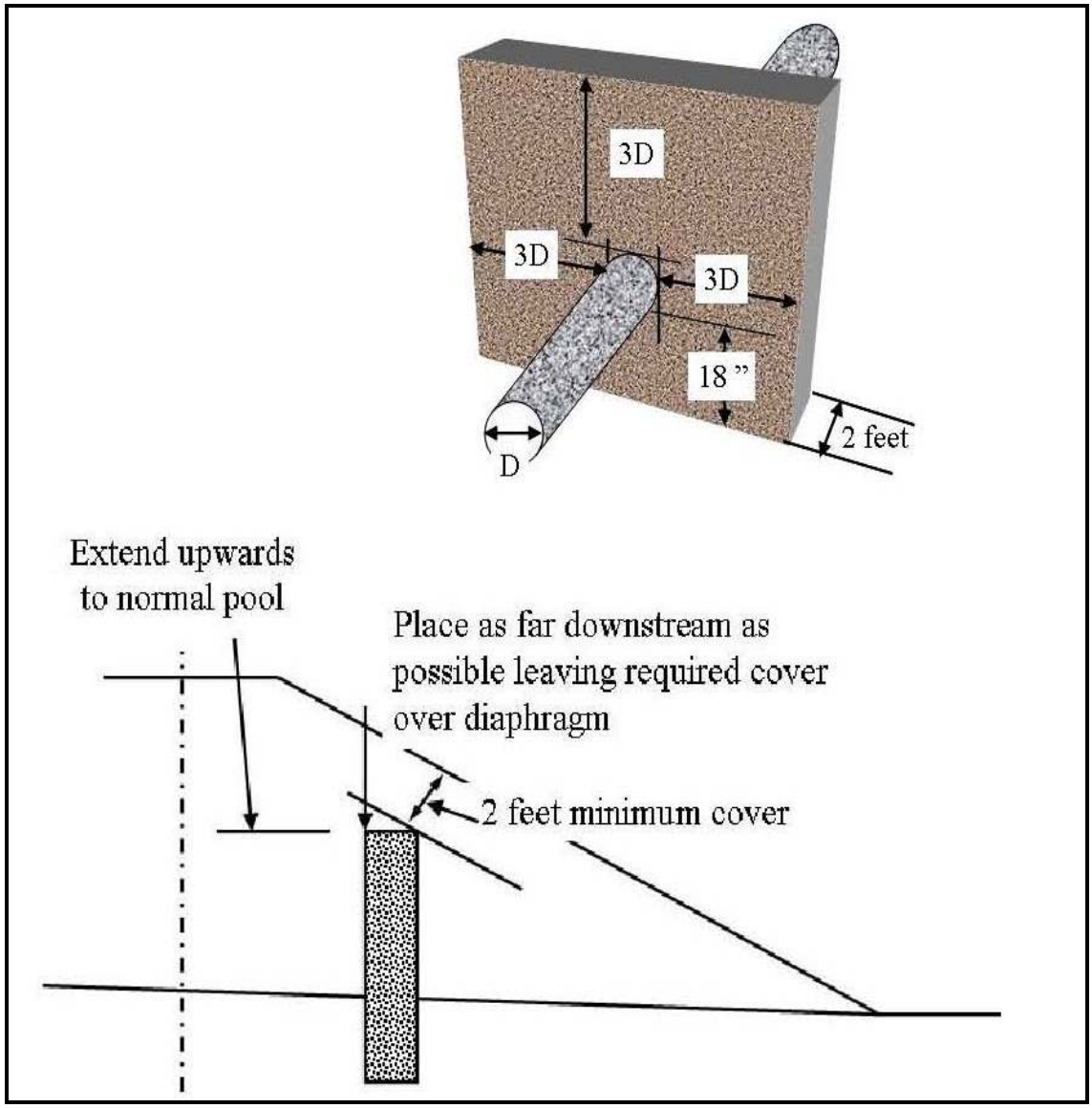


Figure 4.8 Dimensions and Placement of Anti-Seep Collar
(NRCS, National Design Construction and Soil Mechanics Center Technical Note – Filter Diaphragms for CO-01 Structures, August, 2003)

8. The toe of the embankment shall be set back at least 10 feet from the project boundary. The setback shall be measured from the toe of the outer embankment slope to project boundary as shown in Figure 4.8.

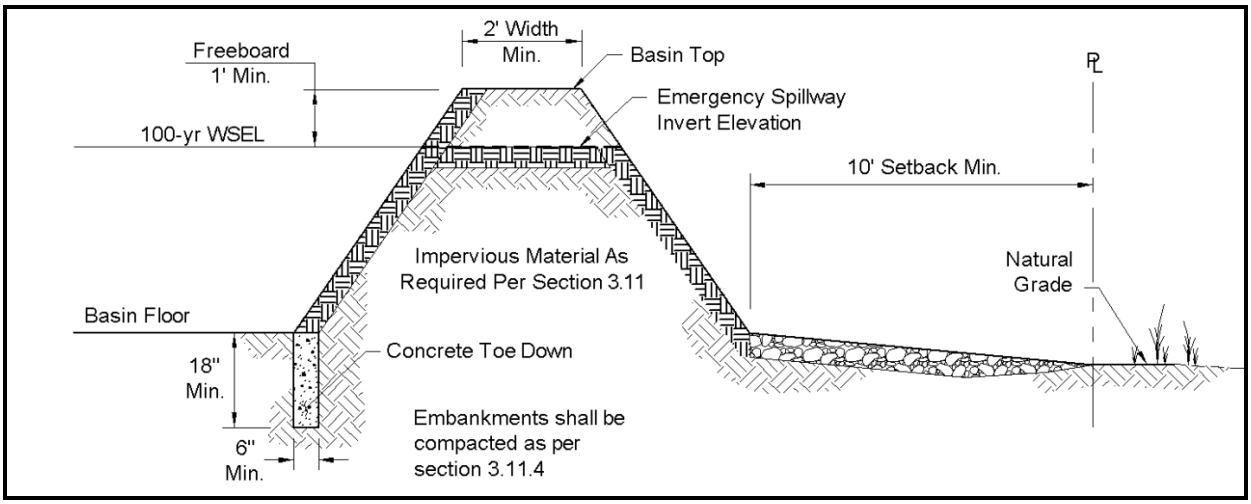


Figure 4.9 Embankment Requirements

9. When embankments are designed to impound greater than 1 foot of water for more than 30 minutes:
    a. An emergency spillway shall be provided,
    b. The emergency spillway invert elevation shall be at the 100-year water surface elevation,
    c. The invert and the downstream side of the emergency spillway, as shown in Figure 4.10, shall be constructed of impervious material,
    d. The design capacity of the emergency spillway shall be the pre-developed 100-year peak discharge outflow rate at a depth of 6 inches. The outlet will not be included in the routing because it is at the 100-year water surface elevation which is the highest water surface elevation used for routing.
    e. The location of the emergency spillway shall not create any adverse impact to surrounding properties,
    f. Impervious treatment shall be provided on the interior slope of the embankments, and
    g. Impervious treatment shall include a toe down which extends 18 inches below the toe of the embankment and shall be at least 6 inches thick, as shown in Figure 4.9.

Photo 4.7 shows an embankment which does not have impervious treatment and which has remained stable in service while impounding levels of water approximately one foot deep or less. Impervious treatment on the interior banks of embankments impounding greater depths of water shall be required in accordance with Section 4.10.1.6.f.

Photo 4.7 Low Embankment Stabilized Without Impervious Treatment

10. When an embankment is located within an erosion hazard setback or regulatory sheet flood area, an engineering analysis shall be provided to determine erosion protection requirements which will protect the embankment from lateral migration of the watercourse.

11. A recorded covenant which specifies inspection and maintenance responsibilities is required when a basin includes an embankment. An example covenant can be found in Appendix A. The covenant shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence Number shall be provided on the Development Plan or Plat adjacent to the embankment location on the plan view.

4.10.2 Embankment Maintenance Requirements

1. Inspections shall be conducted annually and after storm events to ensure the embankment is not damaged due to erosion, piping, sliding, settling or other causes.

2. If damage to an embankment is observed, the embankment shall be restored to the design specifications.

4.10.3 Embankment Prohibition

1. Embankments that are classified as dams pursuant to Arizona Revised Statutes §45-1201 are prohibited.

4.11 Security Barrier

4.11.1 Security Barrier Standards

1. Basins designed for 100-year water depths of more than 2 feet and with side slopes steeper than 4:1 shall have a security barrier at all locations where side slopes are steeper than 4:1.

2. Security barrier shall be a minimum of 42 inches high.

3. The security barrier shall consist of metal, masonry or a combination of the two, meeting the minimum standards in the latest edition of the *City of Tucson/Pima County Standard Details for Public Improvements*.

4. When 100-year water depths exceed 2 feet and pedestrian circulation occurs within 5 feet of the top of a basin, a security barrier shall be constructed. Pedestrian circulation includes ingress/egress to structures, sidewalks, parking or other accessory structures.

5. When vehicle maintenance access is required, a gate or bollards shall be provided at the appropriate location.

4.11.2 Security Barrier Maintenance Requirements

1. Inspections shall be conducted annually and after storm events to ensure the security barrier and surrounding grade are not damaged to the extent that the security of the basin is compromised.

2. If compromising damage is observed, the security barrier shall be restored to design specifications.

4.11.3 Security Barrier Prohibitions

1. The use of vegetation as a security barrier is prohibited.

2. Security barriers shall not restrict the hydraulic capacity of basin inlet and outlet structures.

4.12 Signs

4.12.1 Sign Standards

1. Signs shall be provided to inform the public of the basin purpose, depth and the potential hazard resulting from collection of runoff during a storm event. Example wording is shown in Figure 4.10.

Figure 4.9 Example Sign Which Meets Requirements

2. Signs shall be visible from pedestrian and vehicular access points.

4.12.2 Sign Maintenance Requirements

1. Inspections shall occur annually to ensure the sign is present and not damaged.

2. Damage or vandalism that obstructs visibility of the words on the sign shall be corrected.

4.13 Perimeter Walls

4.13.1 Perimeter Wall Standards

1. When perimeter walls have openings that allow flow to enter into a basin, erosion protection that meets the minimum standards of Section 4.8 shall be provided.

2. When a wall is proposed within 5 feet of the top of a basin slope, a report from an engineer registered in the State of Arizona shall be provided prior to approval of the Improvement Plan that contains at least the following:
    a. The appropriate minimum setback from the top of slope, and
    b. Specific structural design requirements with details.

4.13.2 Perimeter Wall Maintenance Requirements

1. Inspections shall occur annually and after storm events to ensure the perimeter wall and/or erosion at wall openings are not adversely impacting the basin.

2. If adverse impacts are identified, the basin and/or wall shall be restored to the design specifications.

4.13.3 Perimeter Wall Prohibitions

1. Perimeter walls shall not block maintenance access.

2. Perimeter walls shall not restrict the hydraulic capacity of inlet or outlet structures.

3. Perimeter walls are not allowed on embankments.

4.14 Underground Storage

4.14.1 Underground Storage Standards

1. When site constraints prevent a basin from being constructed, underground storage may be allowed.

2. Where underground storage is proposed, failure or blockage of the system shall not pose a hazard to public safety or property. Design considerations include underground storage location and emergency flow conveyance.

3. All stormwater collected during a storm event shall be removed within the disposal time specified in Section 4.5.

4. Underground storage shall have inlets and outlets which meet the design standards found in Sections 4.8, 4.9 and 4.16.

5. Underground storage systems shall provide 1.5 times the required 100-year detention volume.

6. To provide for safe discharge of flow when the volume of an underground storage system is exceeded, an overflow outlet shall be provided which discharges to a drainage path which can convey flow away from structures, electrical equipment, pedestrian pathways, handicap-accessible ramps, hazardous materials, and other areas where stormwater is likely to create damage to health, welfare or property.

7. Per Section 16.36.070 of the Floodplain Ordinance (2010-FC5), the top of any exterior foundation shall extend above the elevation of the inlet a minimum of 12 inches plus 2 percent for a minimum of 25 feet away from the foundation, similar to the above ground inlet shown in Figure 4.10. Pumps shall meet the design requirements of Section 4.19.

8. A recorded covenant which specifies inspection and maintenance responsibilities is required for an underground storage system. An example covenant can be found in Appendix A. The covenant shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence No. shall be provided on the Development Plan or Plat adjacent to the underground storage location on the plan view.

9. Prior to approval of the Tentative Plat or Development Plan, a report from an engineer registered in the State of Arizona shall be provided that contains at least the following:
    a. Appropriate building setbacks from the underground storage system related to structural integrity,
    b. Certification that the load bearing capacity of the soils underlying the underground storage structure is adequate and the soil complex is appropriate bed material,
    c. Structural design details, and
    d. Other design recommendations if appropriate.

4.14.2 Underground Storage Maintenance Requirements

1. Inspections shall occur annually and after storm events to ensure the underground storage system is not damaged and is functioning as designed.

2. When an inspection reveals any of the following, the underground storage system shall be restored to design specifications:
    a. Seepage, settlement, cracking, signs of improper joint alignment or displacement of joints,
    b. Sediment accumulation, and
    c. Damage to or malfunction of pumps, valves, sumps, piping, manifolds or appurtenances.

4.15 Setbacks

4.15.1 Setback Standards

1. For maintenance access, a minimum 10-foot setback from basins and appurtenances, including basin outlets and outer toes of embankments, to the project boundary shall be provided. An example is shown in Figure 4.1.

2. Because soil bearing capacity within a potential zone of saturation may be reduced, structures shall be setback at least 15 feet from a basin, unless an appropriate alternative setback is justified by a geotechnical engineer registered in the State of Arizona prior to approval of the Tentative Plat or Development Plan.

3. The minimum setback from the basin inlet to a structure shall be 25 feet, as shown in Figure 4.10.

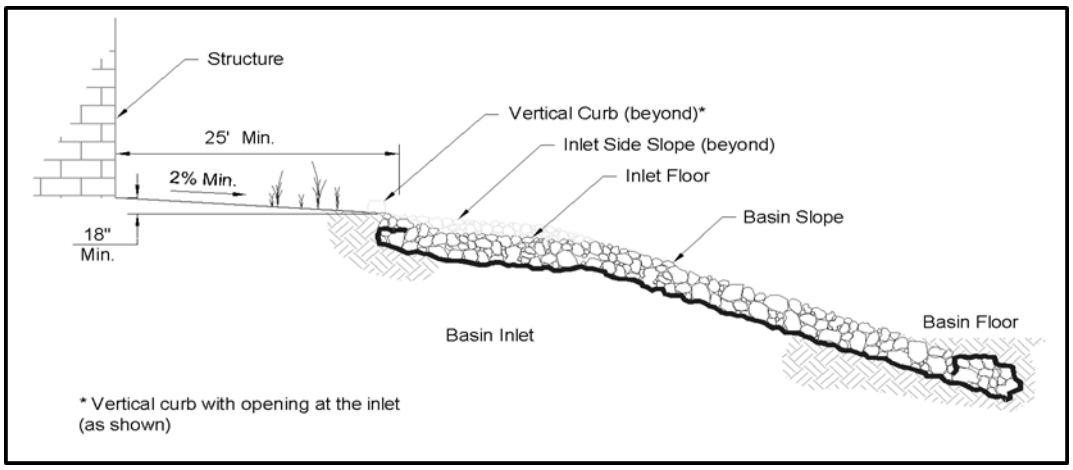


Figure 4.10 Setback and Elevation Requirements for Structures Adjacent to Inlets

4. When a wall is proposed within 5 feet of the top of a basin slope, a report from an engineer registered in the State of Arizona shall be provided prior to approval of the Improvement Plan that contains at least the following:
    a. The appropriate setback from the top of slope, and
    b. Specific structural design requirements with details.

4.15.2 Setback Prohibition

1. Structures, walls, or other obstructions are prohibited within maintenance access setbacks.

4.16 Elevation Requirements

1. Per Section 16.36.070 of the Floodplain Ordinance (2010-FC5), the top of any exterior foundation shall extend above the elevation of the inlet a minimum of 12 inches plus 2 percent for a minimum of 25 feet away from the foundation. Figure 4.10 illustrates this elevation requirement.

2. Any electrical equipment, excluding submersible pumps, within the basin shall be elevated 1 foot above the 100-year water surface elevation of the basin, unless an electrical engineer registered in the State of Arizona certifies that the electrical equipment when inundated does not pose any hazard to public health or safety.

4.16.1 Elevation Maintenance Requirements

1. Electrical equipment shall be inspected annually and maintained to ensure the 1-foot elevation above the 100-year water surface has not been reduced.

4.17 Maintenance Access

4.17.1 Maintenance Access Standards

1. Maintenance access is required for all basins, and the access must be shown on the plans and described in the project drainage report.

2. In order to provide maintenance access, a minimum 10-foot setback from basins and appurtenances, including basin outlets and outer toes of embankments, to the project boundary shall be provided. An example is shown in Figure 4.1.

4.17.2 Maintenance Access Maintenance Requirements

1. Inspections shall be conducted annually and after storm events to ensure access to the basin is not compromised.

4.17.3 Maintenance Access Prohibition

1. Obstruction of maintenance access or a maintenance access ramp is prohibited.

4.18 Landscaping Other Than Riparian Habitat Mitigation

4.18.1 Landscaping Standards

1. Vegetation may be planted on a basin floor or on a basin side slope that is 3:1 or flatter except in areas within a 20-foot radius of the basin inlet, outlet or maintenance access ramp. Plants on the perimeter of a basin shall not obstruct drainage entering or exiting the basin.

2. Plants which can withstand inundation shall be selected.

3. Plants shall be spaced to allow access for maintenance.

4. Trees located adjacent to a required security barrier shall be placed an appropriate distance from the barrier to assure that the tree at maturity does not reduce the structural integrity of the security barrier.

5. Hydroseeding is allowed on the basin floor and 3:1 or flatter side slopes. Plant species used in the seed mix shall be selected from the Approved Plant List provided in Appendix B of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available at: http://rfcd.pima.gov/wrd/riparian/guidelines/pdfs/onsite-guidelines.pdf.

4.18.2 Landscaping Maintenance Requirements

1. Inspections shall occur annually and after storm events to ensure that landscaping has not impacted basin function.

2. If damage is observed, the basin shall be restored to design specifications.

3. Invasive non-native plants shall be removed. A list of the invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available at:
4. http://rfcd.pima.gov/wrd/riparian/guidelines/pdfs/onsite-guidelines.pdf.

5. Any vegetation or debris within the 20-foot radius described in Section 4.18.1. shall be removed.

4.18.3 Landscaping Prohibitions

1. Any vegetation within the 20-foot radius described in Section 4.18.1 is prohibited.

2. Landscaping shall not be located within maintenance access ramps.

3. The use of decomposed granite or rock less than 4 inches in diameter on the basin floor is prohibited.

4. Invasive non-native plants located within a basin are not allowed.

4.19 Pumps

4.19.1 Pump Standards

1. The use of a pump may be allowed if site constraints prevent the basin from having positive drainage. Site constraints may include topography, existing infrastructure and conflicting code requirements. Approval to use a pump shall be obtained from the District prior to the first submittal of the Tentative Plat or Development Plan.

2. If a pump is proposed, the detention system shall provide an emergency spillway directed to a local watercourse that does not cause an adverse impact to the watercourse or neighboring properties and one of the following:
    a. Additional basin volume to contain the entire volume of the 100-year post-developed hydrograph from the drainage area contributing to the basin, or
    b. A back-up pump with an emergency power source. If an emergency back-up generator is proposed, the generator shall be elevated 1 foot above the 100-year water surface considering total pump failure or shall be waterproofed.

3. Service equipment (excluding components whose design requires submersion) shall be set at an elevation 1 foot above the unattenuated 100-year water surface elevation, considering total failure of the pump system.

4. Outlets shall be designed to meet the requirements found in Section 4.9.

5. Pumps shall be in an accessible location for routine maintenance and emergency service.

6. Basins with a pump shall meet the storage time standards found in Section 4.5.

7. The pump's discharge rate shall not exceed the pre-developed conditions 2-year peak discharge rate.

8. The collection system shall discharge into a separate sump that screens the water before entering the pump sump. The sump location and dimensions shall be shown on the plan set.

9. A clogging factor of 2.0 shall be used for the trash rack/screen design.

10. The pump shall be designed to pass 3-inch solids.

11. A pump shall be provided with an automatic control switch with a vertical float mechanism as well as a manual control.

12. A potable water supply with hose bibs shall be provided to aid in removal of silt and trash.

13. Each pump shall have an alarm system for high water and low water alarm with, at minimum, the following:
    a. A light that provides a visual alert,
    b. The name and phone number of a responsible party clearly displayed on the pump housing and alarm system,
    c. Housing that is vandal proof and weather resistant, and
    d. Other District recommendations if appropriate.

14. A recorded covenant which specifies inspection and maintenance responsibilities is required when a pump is used as a method of stormwater disposal. An example covenant can be found in Appendix A. The covenant shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence No. shall be provided on the Development Plan or Plat adjacent to the pump location on the plan view.

15. The project's Drainage Report shall provide the following information:

a. Emergency back-up plan,
b. Drainage exhibit showing drainage flow under clogged conditions,
c. Maintenance Plan with at minimum the following:
    i. Maintenance schedule,
    ii. Type of maintenance activities,
    iii. Exhibit showing the location of the pump, alarm systems and other equipment, and
    iv. Copy of the covenant.

1. A pump system analysis shall be submitted for District review and approval with the Tentative Plat or Development Plan. The analysis shall include:
    a. Site Data
        i. Contributing drainage area(s),
        ii. Location of outfall,
        iii. Capacity of outfall, and
        iv. Inflow hydrograph(s).
    b. Pump System Components
        i. Specifications for the model and type of pump(s) proposed including pump curves (single pump and parallel operation). Overloading the pump anywhere on the pump curve is not permitted,
        ii. Location and specifications for intakes and catch basins,
        iii. Controls and alarm system,
        iv. Debris handling,
        v. Location of potable water supply, and
        vi. Location and design of emergency overflow.
    c. Hydrologic/Hydraulic Analysis
        i. Headloss calculations for the entire system, including maximum and minimum Total Dynamic Head (TDH) and flow rate,
        ii. Net positive suction head (NPSH) and pump level settings for on, off and alarm positions, and
        iii. Inflow and outflow hydrographs and accumulated inflow and outflow curves (mass flow curves). The use of HEC-HMS is not appropriate for the design of pump systems. A real-time procedure which routes the design inflow hydrograph using pump on and off elevations and actual pump performance curves must be used.

4.19.2 Pump Maintenance Requirements

1. Inspections shall be conducted annually, after storm events and after the alarm system is activated to ensure the pump is not damaged and is functioning as designed.

2. Prior to the summer and winter rainy seasons, the pump, back-up system and alarm system shall be operated to ensure the system is functioning as designed.

3. If damage/malfunction is observed, the system shall be restored to design specifications.

4. Trash and debris shall be removed from the pump system and properly disposed.

5. The site layout shall consider adequate access for maintenance vehicles and removal of equipment for repair.

4.20 Dry Wells

4.20.1 Dry Well Standards

1. When site constraints justify use of a dry well or dry wells to dispose of detention volume, approval to include a dry well or dry wells in basin design shall be obtained from the Floodplain Administrator prior to the first submittal of the Tentative Plat or Development Plan. When requesting the approval, the engineer must submit field investigation results and a preliminary site plan.
    a. The field investigations shall include:
        i. Logs for soil borings to the anticipated depth of the dry well,
        ii. Determination of depth to groundwater in the proposed locations of dry wells, and
        iii. A percolation testing report by a Geotechnical Engineer registered in the State of Arizona. The percolation testing report shall include the testing methods and results.
    b. The preliminary site plan shall include at minimum:
        i. The location of the proposed dry well(s) and test well(s),
        ii. The location of the proposed structure(s) with the building footprint,
        iii. Parking lot layout including pedestrian circulation, and
        iv. The general drainage scheme.

2. Where a dry well is proposed, failure of the system shall not pose a hazard to public safety or property.

3. Dry wells shall be registered with the Arizona Department of Environmental Quality (ADEQ) and designed, operated, and maintained in conformance with the most current ADEQ guidelines.

4. To obtain percolation rates to use in the design of the dry well(s) a percolation test shall be performed to determine a stabilized infiltration rate.

5. Test results shall be de-rated, using Equation 4.1, based on the in-situ soil conditions. De-rating is required to compensate for deterioration of the percolation capacity over time and to provide a factor of safety for silting and grate obstruction

Equation 4.1 $$P_d = \frac{P_r}{D_r}$$

Where:

P_d = the design percolation rate in inches/hour,
P_r = the measured stabilized percolation rate in inches/hour, and
D_r = the de-rating factor.

a. The following de-rating factors shall be used:
   i. A de-rating factor of 2 for coarse-grained soils (cobbles, gravels and sands),
   ii. A de-rating factor of 3 for fine grained soils (silts and loams), and
   iii. A de-rating factor of 5 for clay soils.
b. The design disposal rate for a dry well, after application of the de-rating factor, should not be less than 0.1 cfs per well, and
c. The maximum allowable rate, after application of the de-rating factor, is not recommended to exceed 1.0 cfs per drywell for design purposes.
d. Upon approval of performance, adjusted as presented above, a test well may then be used as one of the functioning dry wells for the project.

6. Dry wells shall be located into a permeable porous stratum to provide a minimum distance of 10 feet between the water table or an impermeable layer and the base of the injection screen and shall be a minimum distance of 100 feet from any water supply well.

7. If dry wells are the sole method of outflow, the basin must be sized to contain the base flood hydrograph without outflow.

8. When dry wells are proposed in basins without stormwater harvesting or first-flush retention, the basin floor shall be sloped at a minimum .5% to assure that all wells are utilized for lower water levels.

9. Multiple drywells shall be spaced a minimum of 100 feet apart.

10. A dry well shall be located a minimum of 20 feet from the basin inlet.

11. If landscaping is proposed on the basin floor, the dry well inlet shall be raised 3 inches above the basin bottom elevation.

12. The dry well location shall be in an accessible location for routine maintenance and inspection and shall be protected from damage by vehicles.

13. The infiltration/percolation rate of the dry well shall meet the storage time standards found in Section 4.5. Dry wells that do not meet this standard shall be replaced or refurbished by the owner or a representative.

14. The design of a dry well shall include provisions for trapping sediment within a settling chamber.

15. The system shall use a floating absorbent blanket or pillow to enhance the removal of petroleum-based organics floating on the water, and a hydrophobic petrochemical absorbent with a minimum capacity of 100 ounces per chamber shall be provided.

16. During site development, all dry wells shall be securely covered with filter cloth or other material to prevent the introduction of excessive sediment into the settling chamber. Prior to Release of Assurances for plats and prior to Certificate of Occupancy for development plans, dry wells shall be re-tested. If a dry well has been compromised during construction, the dry well shall be restored to design specifications prior to Release of Assurances for plats or prior to Certificate of Occupancy for development plans.

17. Landscaping shall be installed a minimum of 4 feet from the perimeter of the bolted ring and grate.

18. The words “Stormwater Only” shall be stamped in raised letters on the drywell grate.

19. A recorded covenant which specifies inspection and maintenance responsibilities is required when a dry well is used as a method of stormwater disposal. An example covenant can be found in Appendix A. The covenant shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence No. shall be provided on the Development Plan or Plat adjacent to the dry well location on the plan view.

20. A typical drywell installation is shown in Figure 4.11.

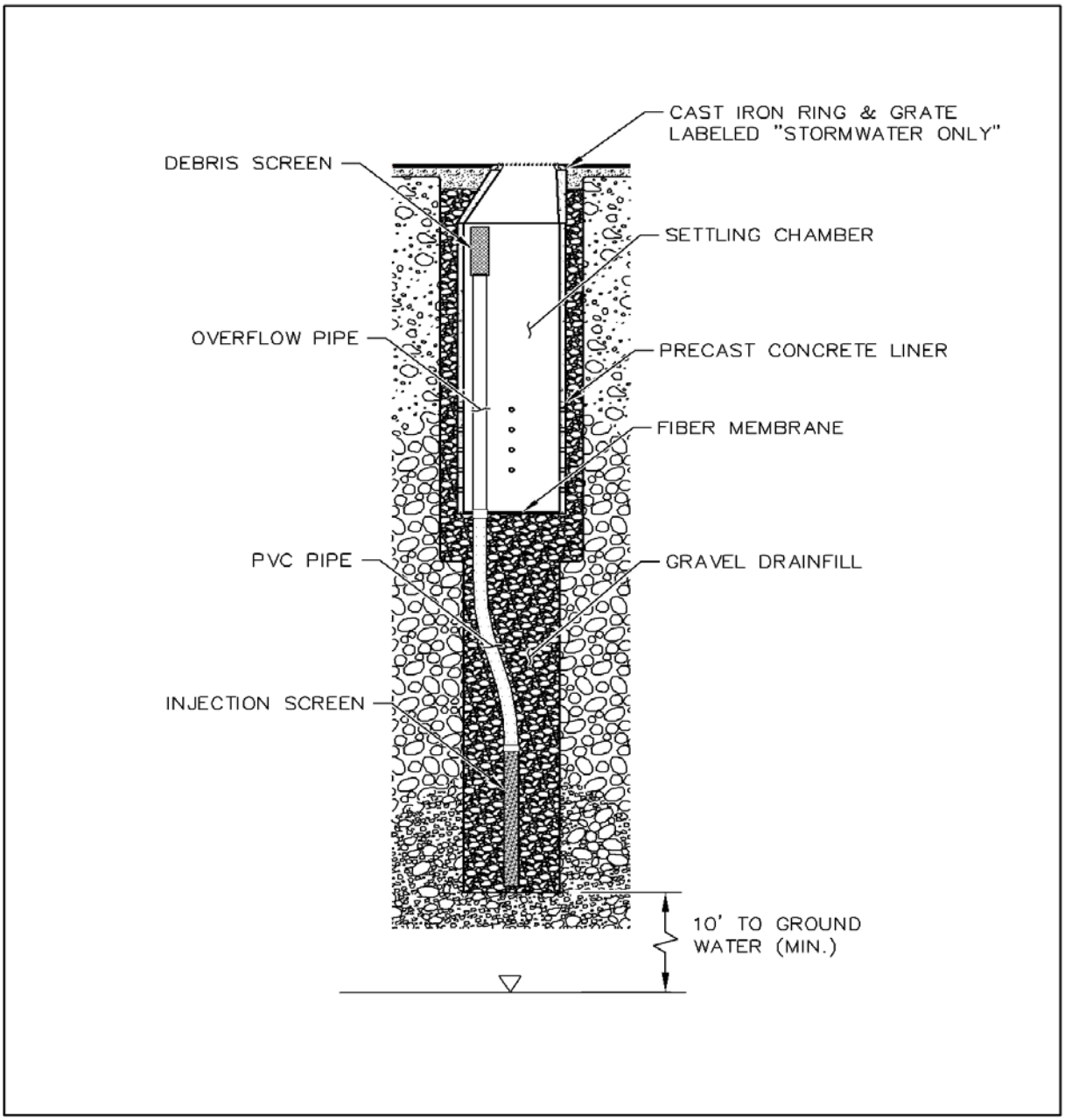


Figure 4.11 Typical Dry Well Installation

21. The project's Drainage Report shall provide the following information:
    a. Design by a licensed professional,
    b. Plan for stormwater disposal in the event the drywell(s) cease(s) to function,
    c. Maintenance Plan with at minimum the following:
        i. Maintenance schedule,
        ii. Type of maintenance activities,
        iii. Exhibit showing the location(s) of the drywell(s),
        iv. Contact information of the driller or authorized maintenance

v. professional, and
vi. A copy of the covenant.

4.20.2 Dry Well Maintenance Requirements

1. Inspections shall be conducted annually and after significant storm events to ensure the dry well and settling chamber are functioning as designed.

2. If an inspection identifies that the dry well is not infiltrating within the storage limits outlined in Section 4.5.1, or other damage or maintenance requirements are identified, the maintenance shall be performed to restore the drywell(s) to design specifications.

3. Accumulated debris, weeds and trash shall be removed from the surface.

4. Sediment shall be removed from the settling chamber when approximately 15 to 20% of the original volume of the chamber is filled.

5. All sediment removed from a settling chamber shall be disposed of at an authorized sanitary landfill.

6. Maintenance requirements shall be provided in the restrictive covenants for subdivisions where dry wells are used.

4.20.3 Dry Well Prohibitions

1. Disposal methods using infiltration shall not be permitted for stormwater runoff which carries significant concentrations of sediment. This includes stormwater runoff flowing through sand bed channels, as well as stormwater runoff emanating from a predominantly natural watershed.

2. Drywells are prohibited for industrial developments.

3. In multi-use basins, drywell inlets shall not pose a hazard to pedestrian safety.

4. Landscaping shall not impair drywell function.

5 LOW IMPACT DEVELOPMENT DESIGN STANDARDS

Low Impact Development (LID) requires a shift in stormwater management away from conveying runoff to a small number of downstream points through hydraulically efficient infrastructure toward retaining and using the runoff as close as possible to the source of the runoff. The use of distributed stormwater management infrastructure should be evaluated during site planning and site design.

During site planning, the planner must also consider the site's natural hydrology when locating proposed improvements. The planner should identify hydrologic features including existing flow paths, areas with higher permeability soils, and riparian areas. Objectives of LID are to minimize the impact to these areas and to attempt to mimic natural hydrologic processes in impacted areas.

Another goal of site planning is to design the development to function within the smallest possible footprint.

Once site planning is completed, the designer must consider the appropriateness of other LID practices that can be constructed to reduce runoff discharge rates and volumes by slowing down flow and retaining runoff for beneficial use.

This chapter provides minimum criteria for constructed LID practices proposed during site design.

5.1 Low Impact Development General Requirements

1. Projects shall retain the first 0.5 inch of rainfall that flows off of impervious and disturbed surfaces (first-flush retention). The applicant may demonstrate that the required retention volume, calculated by Table 2.1, is provided within stormwater harvesting basins or other LID practices or within a detention basin. The use of stormwater harvesting and other LID practices is optional.

2. Site planning shall occur to minimize disturbed, compacted and connected impervious surfaces and to protect and enhance regulated riparian habitat and regulatory floodplains.

3. Where present, connections between impervious and disturbed areas shall be minimized.

4. LID practices shall be distributed throughout the project site.

5. Inspection and Maintenance Plans are required for all projects using LID practices. The Inspection and Maintenance Plans shall be reviewed and approved by the District prior to approval of the Tentative Plat or Development Plan.

6. To allow for inspection and maintenance, LID practices shall be legally and physically accessible.

7. Upon completion of construction of all LID practices, an as-built certification shall be prepared and submitted to the District. The as-built certification shall be used by the responsible party when performing periodic inspections and maintenance when restoring the LID practices to design specifications, if required.

8. When LID practices are to be maintained by a private entity, such as a Homeowners Association, this responsibility shall be described in the association's Covenants, Conditions and Restrictions which shall refer to the Inspection and Maintenance Plan and As-Built Plan.

5.2 Low Impact Development General Prohibitions

1. Although the use of stormwater and rainwater harvesting facilities on private residential lots is encouraged, any retention volume on private residential lots shall not be counted towards the first-flush retention or detention requirement.

2. The volume of rainwater harvesting cisterns or other practices that do not allow for infiltration of runoff to occur shall not be counted towards satisfying the first-flush retention requirement.

5.3 Stormwater Harvesting Basins

5.3.1 General Standards for Stormwater Harvesting Basins

The following standards are applicable to all stormwater harvesting basins, other than Non-Contributing Area Basins. Standards for Non-Contributing Area Basins are provided in Section 5.3.4.

1. Stormwater harvesting basins shall be located so that the basin can effectively capture and retain stormwater.

2. Stormwater harvesting basins shall be designed to retain no more than 9 inches of stormwater. The depth is measured from the lowest elevation on the basin floor to the 100-year water surface of the basin.

3. Basin floors shall allow for uniform ponding across the entire basin.

4. When terraced cells are proposed, each cell of a terraced basin may be considered separately when determining basin depth and each cell shall allow for uniform ponding.

5. Stormwater harvesting basins shall be constructed entirely below finished grade.

6. Minimum freeboard for stormwater harvesting basins and Type 1 Non-Contributing Area Basins is 3 inches. Minimum freeboard for Type 2 Non-Contributing Area Basins is 6 inches.

7. All side slopes of a stormwater harvesting basin shall be 3:1 or flatter unless the side slope is rock lined.

8. Stormwater harvesting basins shall be designed with an inlet. The inlet shall meet the following criteria:
    a. The inlet shall be located to accept flow from the contributing watershed.
    b. Inlet erosion protection shall be placed at a width sufficient to encompass flow expansion downstream of the inlet and consist of 4-inch angular rock hand-placed in two layers on filter fabric, as shown in Figure 5.1.
    c. When a stormwater harvesting basin is located adjacent to a parking area, the inlet shall be sized to prevent ponding greater than 1 foot deep during the 100-year event within the parking area.

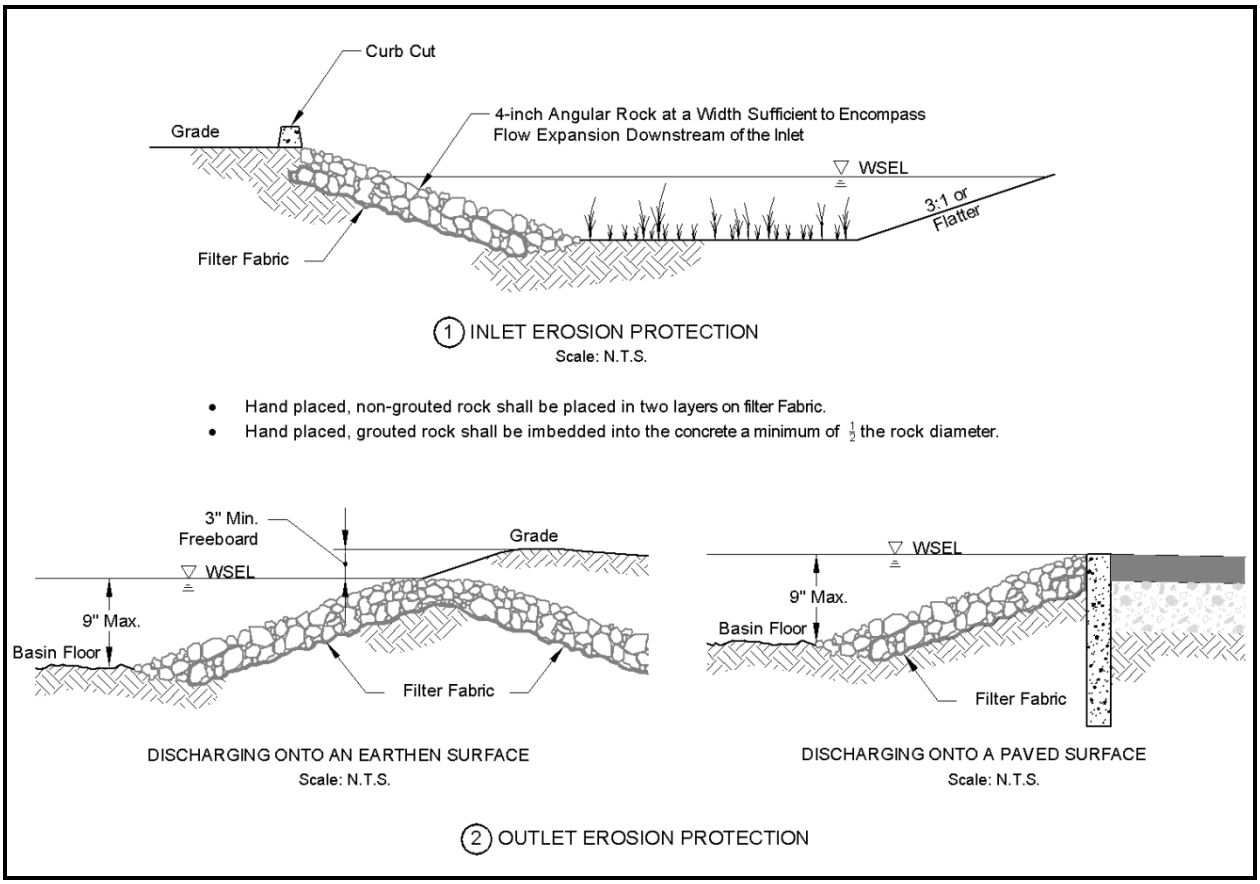


Figure 5.1 Inlet and Outlet Erosion Protection for Stormwater Harvesting Basins

9. When an outlet is proposed, the outlet shall meet the following criteria:
    a. The outlet shall be located where it does not pose a hazard to pedestrian circulation or create an adverse impact to structures, infrastructure or adjacent properties. The outlet discharge shall not exceed the capacity of downstream infrastructure or balanced or critical basin discharge requirements.
    b. Outlet erosion protection shall consist of either:
        i. As shown in Figure 5.1, for outflows onto earthen surfaces, 4-inch minimum angular rock at a width sufficient to encompass flow expansion downstream of the outlet. Hand-placed non-grouted rock shall be placed in two layers on filter fabric. Hand-placed grouted rock shall be embedded in concrete a minimum of ½ the rock diameter; or
        ii. For outflows onto pavement, a 4" thick concrete cut-off wall shall be placed at the outlet extending to the basin floor, as shown in Figure 5.1.

10. When stormwater harvesting basins with terraced cells are proposed, internal check dams to pond water shall be provided.

a. The minimum freeboard shall be measured from the top of the check dam to the lowest finished grade adjacent to each cell.
b. The check dams shall consist of an earthen berm with 3:1 slopes or flatter that extends the width of the cell with a layer of 4" minimum angular rock over filter fabric that extends to the toe of the berm on both the upstream and downstream slopes of the berm.
c. All rock on check dams shall be keyed in a minimum 12 inches into the side of the basin.

11. For safety and access purposes, stormwater harvesting basins shall have the following setbacks, as measured from the top of the basin slope:
    a. Minimum 1 foot of flat surface between a sidewalk or pedestrian access area.
    b. Minimum 10 feet from structures, or minimum setback specified in a geotechnical report for the project.
    c. Minimum 5 feet from the property boundary for maintenance access, and
    d. Minimum 2 feet from the back of curb when located adjacent to a street with on-street parking.
    e. Minimum 6" from the back of curb when located adjacent to a street where there is no on-street parking.
    f. Minimum 2 feet from the edge of a parking area.

12. Landscaping within stormwater harvesting basins is encouraged.
    a. All areas within a stormwater harvesting basin except for check dams may be used for planting area, and
    b. Planting domes or other raised areas on the basin floor are acceptable as long as retention volume is maintained.
    c. Hydroseeding is allowed within a stormwater harvesting basin. The seed mix shall have plant species from the Approved Plant List provided in Appendix B of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available at: http://rfcd.pima.gov/wrd/riparian/guidelines/pdfs/onsite-guidelines.pdf.

13. Except for roadside stormwater harvesting basins, LID practices in subdivisions shall be located in Common Area designated for Drainage.

5.3.2 Roadside Stormwater Harvesting Basins

When a roadside stormwater harvesting basin is proposed to be located within a public right-of-way, a right-of-way use permit must be obtained prior to construction. Written permission from the jurisdiction shall be submitted with the Tentative Plat or Development Plan.

When a roadside stormwater harvesting basin is proposed to be located adjacent to a private street, the basin should be located within Common Area or within a drainage easement.

Whether the location is public right-of-way or private property, site design shall include careful consideration of the location of utilities and access points.

The following standards apply to stormwater harvesting basins that are located adjacent and parallel to a street for the purpose of collecting runoff from the street.

1. Curb openings for roadside stormwater harvesting basins shall meet the following criteria:
   a. Curb openings shall be separated from driveway aprons and other curb openings by a minimum distance of 10 feet,
   b. Curb openings shall be located a minimum of 20 feet from an end of a curb return (corner),
   c. Curb openings proposed on existing curbs (retrofit) shall be made by a saw cut method, and
   d. Curb openings shall be a maximum of 2 feet in width with 45-degree sloped sides.
   e. The bottom of the curb cut shall be a minimum 4” below any other point along the edge of the basin.

2. Basin side slopes shall be 3:1 or flatter.

3. Adjacent to sidewalk, pedestrian access or parking, the top of the basin shall be a minimum of 1 foot from the edge of the sidewalk, pedestrian access, or parking area.

4. Roadside stormwater harvesting basins shall located a minimum of 2 feet from the back of curb.

5. Roadside stormwater harvesting basins shall be a maximum of 9” in depth.
   A typical cross-section is provided in Figure 5.2.

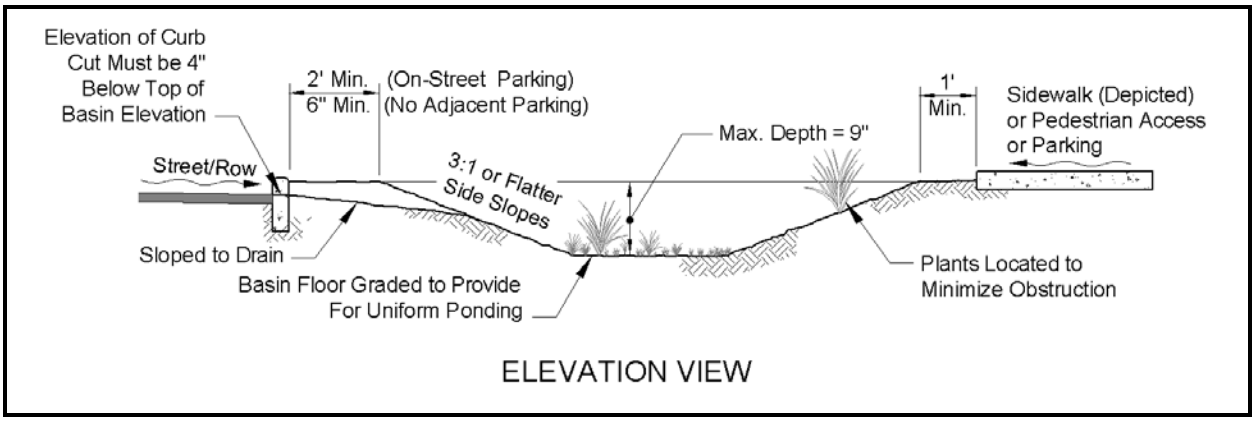


Figure 5.2 Roadside Stormwater Harvesting Basin

5.3.3 Stormwater Harvesting Basins Adjacent to Parking Areas

When stormwater harvesting basins are proposed adjacent to parking areas, the top of the basins shall be separated horizontally from edge of the parking area by a minimum of 1 foot.

5.3.4 Non-contributing Area Basin Standards

Non-Contributing Area basins are basins designed to retain the full 100-year stormwater volume and can be excluded from calculations to determine post-development peak discharges. Non-Contributing Area Basins shall be designed to meet the following standards:

1. The minimum water storage depth shall be 6 inches.

2. The maximum water storage depth shall be 9 inches.

3. A minimum of 3 inches of freeboard shall be provided for Type 1 Non-Contributing Area Basins, and a minimum of 6 inches of freeboard shall be provided for Type 2 Non-Contributing Area Basins.

4. Non-Contributing Area Basins shall be located where they do not pose a safety hazard or create an adverse impact to adjacent properties and structures.

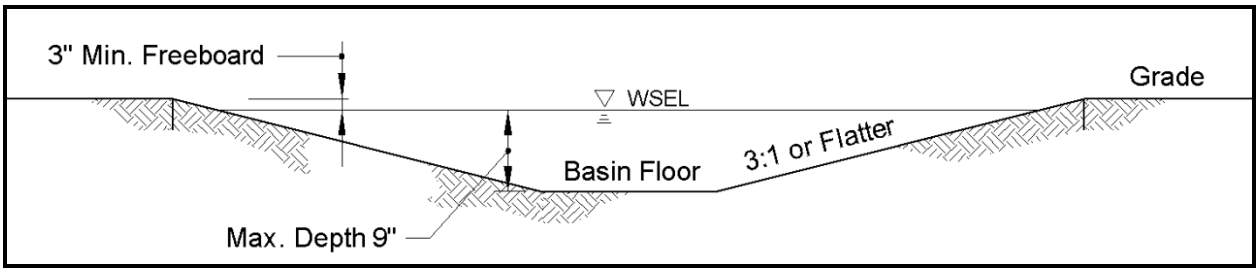
5. Basin bottoms shall provide for uniform ponding.

6. Side slopes shall be 3:1 or flatter.

7. For Type 2 Non-Contributing Area Basins, the ratio of the upstream drainage area to the pervious basin bottom for the Non-contributing Area Basin shall not exceed 2:1.

8. The use of parking and access lane areas for retention is allowed for Type 2 Non-Contributing Area Basins.

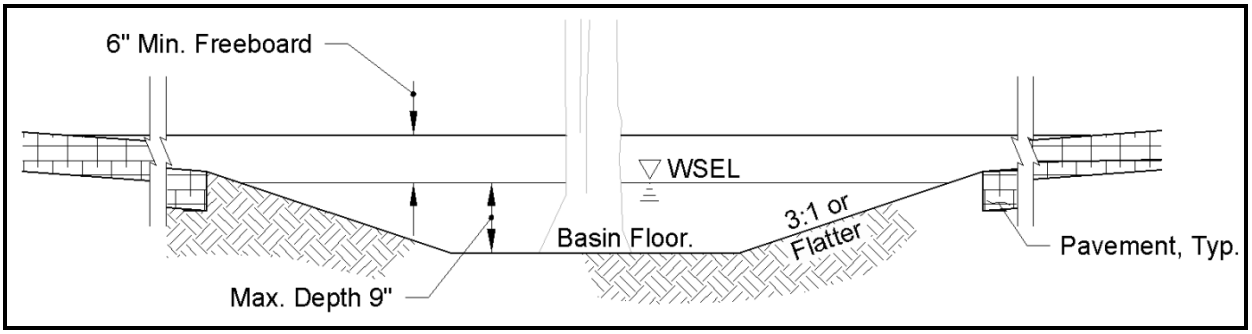
The standards are illustrated in Figure 5.3 and Figure 5.4.



- Designed without inlets

- Retain the 100-year rainfall volume on contributing area
- Maximum basin depth is 12”
- The impervious to pervious ratio shall not exceed 2:1

Figure 5.3 Type 1 Non-Contributing Area Basin



- Designed without inlets
- Retain the 100-year rainfall volume on contributing area
- Maximum basin depth is 15”
- The impervious to pervious ratio shall not exceed 2:1

Figure 5.4 Type 2 Non-Contributing Area Basin

5.3.5 Bioretention Basin

Bioretention basins are engineered basins consisting of an over-excavated area that is replaced with a constructed soil medium to aid in runoff storage and infiltration.

1. The bioretention basin shall consist of:
    a. A sub-base consisting of an 8-inch bottom layer of coarse aggregate (gravel) that is washed to be free of fine material,
    b. A woven geo-textile fabric, installed per the manufacturer’s specifications, placed between the sub-base and the constructed soil medium, and
    c. A constructed soil medium that is a mixture of sand (85% ASTM C-33 sand by volume) and organic material (15%) such as peat, top soil, mulch, or compost and shall be fully mixed in a drum mixer. The constructed soil medium shall not

be more than 24 inches thick. Alternative soil media require prior approval by the District.

2. The bioretention basin shall have a flat topped surface that is depressed a minimum of 6 inches and a maximum of 12 inches below adjacent finished grade. Side slopes shall be 3:1 or flatter.

3. Because soil bearing capacity within a potential zone of saturation may be reduced, bioretention basins shall be set back horizontally from a structure a minimum of 5 feet or twice the depth of the constructed soil medium, whichever is greater, unless an appropriate alternative setback is justified by a geotechnical engineer registered in the State of Arizona prior to approval of the Tentative Plat or Development Plan.

4. Bioretention basins shall provide a sediment trap located at the downstream end of the inlet.

5. A vertical inspection pipe shall be provided in order to assess the effectiveness of the bio-retention basin. The pipe shall be perforated 4-inch PVC or equivalent and shall extend from the bottom of the gravel sub-base to the top of the constructed soil medium with a removable cap. See Figure 5.5.

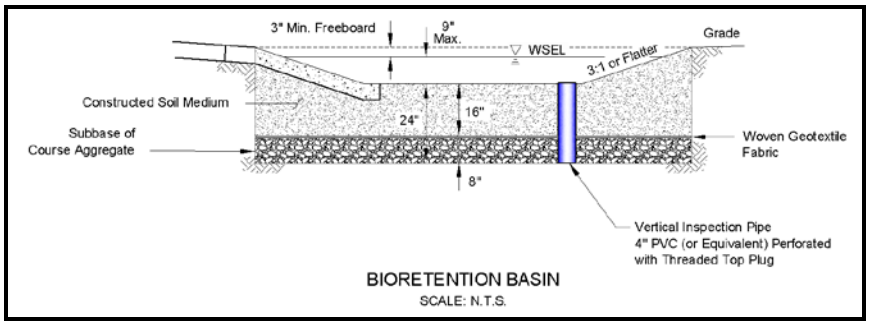


Figure 5.5 Bioretention Basin

5.4 Stormwater Harvesting Basin Maintenance

1. Stormwater harvesting basins shall be maintained to perform as designed for the life of the project and shall not be converted to a different use without review and approval by the District.

2. Stormwater harvesting basins shall be inspected annually and after storm events to ensure the basins are performing as designed. If ponding is observed after more than 24 hours, the soil should be loosened in the basin bottom to promote infiltration.

3. Inlets and outlets shall be maintained free of obstructions.

4. Conveyances to the basins shall be maintained to be free of leaves, debris, or other obstructions.

5. The depth of the stormwater harvesting basin shall be inspected annually to ensure the design volume is maintained.

6. Slopes shall be maintained to the original design configuration.

7. Soil with evidence of oil, grease or other chemicals shall be removed and disposed of properly and the basin returned to the original design specifications.

5.4.1 Bioretention Basin Maintenance

In addition to the maintenance requirements provided above, these additional maintenance requirements apply to bio-retention basins.

1. Access to the vertical inspection pipe shall be maintained in order to determine if there is standing water in the constructed soil medium or if infiltration is occurring. If infiltration rates are declining or not occurring, replacement of the medium or other method of retention is required.

2. Debris and litter in the detention area shall be removed to minimize clogging of the sand media.

5.5 Stormwater Harvesting Basin Prohibition

The following prohibition applies to stormwater harvesting basins.

Invasive non-native plants located within a stormwater harvesting basin are not allowed and must be removed if found within the basin. A list of the invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available at:
http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

5.6 Retention Within A Detention Basin

A retention area for first-flush retention or stormwater harvesting may be constructed within a detention basin. Areas not designated for retention may be used for landscaping or riparian habitat mitigation. The following standards, illustrated in Figure 5.6, apply:

1. A maximum of 9 inches of retention is allowed. The depth is measured from the lowest elevation on the basin floor to the lowest outlet invert elevation.

2. The retention area shall connect the basin inlet to the outlet, and meet the following criteria:
    a. The width of the retention bottom area shall be a minimum of 4 feet to allow for maintenance of this area,
    b. Planting of vegetation in the retention area is prohibited,
    c. The use of check dams in the retention area in order to create cells of uniform depth is allowed.
    d. The retention area floor shall provide for uniform ponding.
    e. Retention areas shall have 3:1 or flatter earthen side slopes.

3. If vegetated areas on terraces above the retention area are proposed, the following apply:
    a. Berms to harvest stormwater are allowed on the terraces.
    b. If bermed, terraces shall provide for uniform ponding. Planting terraces shall be elevated to the top of the retention area.

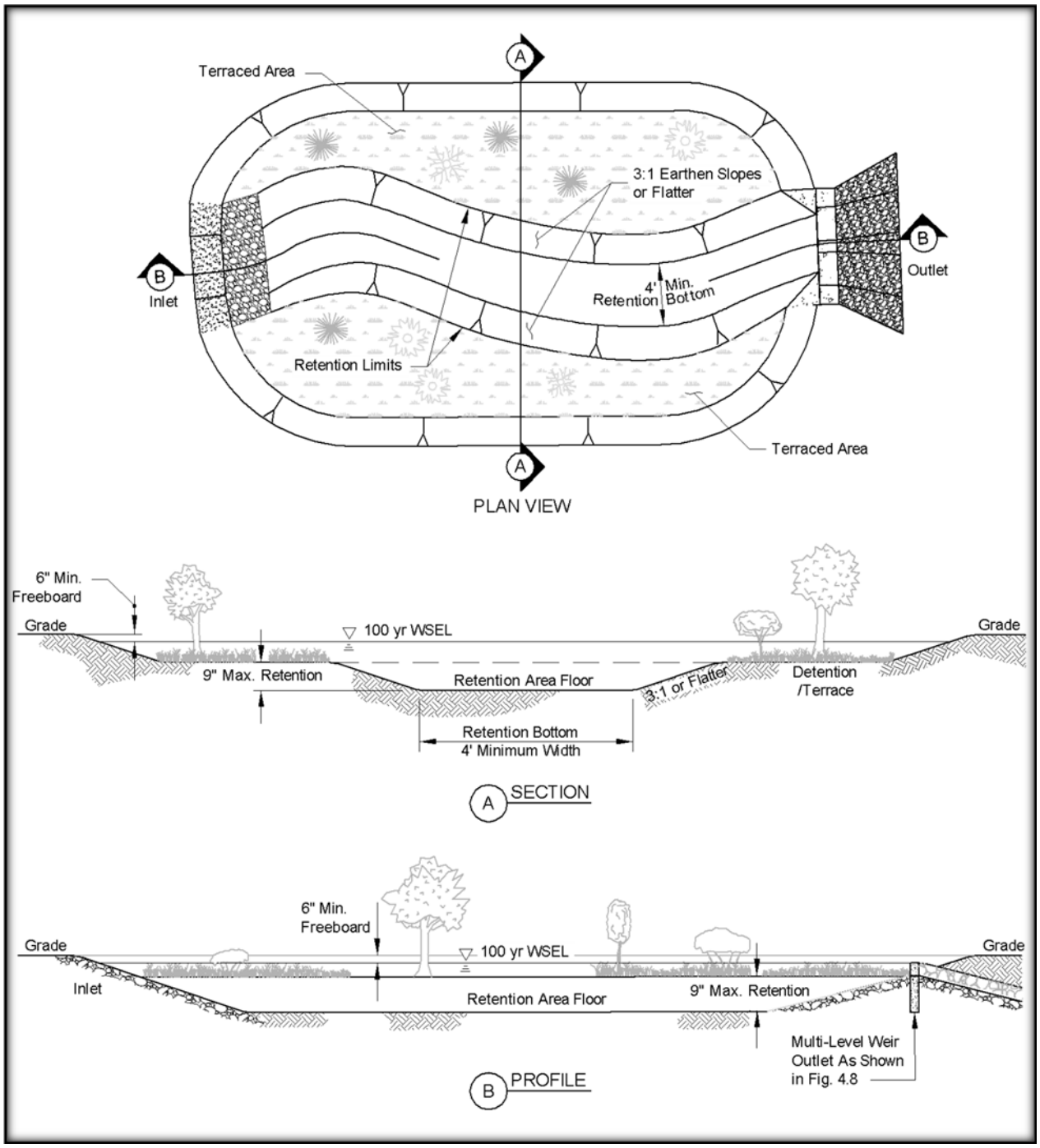


Figure 5.6 Terraced Detention Basin with Retention

5.7 Retention Within A Detention Basin Maintenance

1. Retention areas shall be maintained to perform as designed for the life of the project and shall not be converted to a different use without review and approval by the District.

2. Retention areas shall be inspected annually and after storm events to ensure the retention area is performing as designed. If ponding is observed after more than 24 hours, the soil should be loosened in the basin bottom to promote infiltration.

3. The retention area floor shall be maintained free of vegetation, debris and other obstructions.

4. The depth of the retention area shall be inspected annually to ensure the design volume is maintained. Sediment and other deposits shall be removed when the depth from the top of the retention area to the basin floor is less than 6."

5. Slopes shall be maintained to the original design configuration.

6. Soil with evidence of oil, grease or other chemicals shall be removed and disposed of properly and the basin returned to the original design specifications.

5.8 Retention Within A Detention Basin Prohibitions

The following prohibitions apply to retention areas within detention basins.

1. Invasive non-native plants located within a retention area are not allowed and must be removed if found within the basin. A list of the invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available at: http://rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_jan2010.pdf.

5.9 Practices That Increase The Time Of Concentration

Peak discharge rates may be reduced through the use of a site design which allows for increased infiltration. This can be accomplished by increasing the length of the flow path, by flattening slopes, and by roughening the surface. When these practices are proposed, the following standards apply:

5.9.1 Lengthened Flow Path Standards

Lengthened flow paths shall occur in swales or channels which meet the following criteria. A channel or swale qualifies as a conveyance designed to lengthen flow path when it provides a longer flow path than the shortest, most linear, most direct route between upper and lower portions of a site watershed.

1. Swales and channels shall meet current channel design standards, including freeboard.

2. When 100-year flow velocities are 2 feet per second or less, earthen swales are allowed. Earthen swales may be allowed for higher 100-year velocities when a project site soils sieve analysis prepared by a geotechnical engineer registered in the State of Arizona is

submitted, along with acceptable engineering justification of a higher value based on acceptable methods such as those provided in the Federal Highway Administration's Highways in the River Environment or those adopted by the Natural Resources Conservation Service.

3. When 100-year flow velocities are greater than 2 feet per second, swales shall be rock lined unless an engineering analysis justifies that no erosion protection is necessary.

4. Swales may be lined with angular rock with a D50 of at least 4 inches to roughen the flow path.

6 Multiple-Use Concepts

Use of a detention basin for multiple purposes is practical and feasible in many locations. Acceptable uses are human activity, such as passive and active recreation, and landscape buffer yards. The following requirements apply when a detention basin provides for uses other than detention.

6.1 Basins Designed With Human Activity Zones

6.1.1 General Requirements

1. Any electrical equipment, excluding submersible pumps, within the basin shall be elevated 1 foot above the 100-year water surface elevation of the basin, unless an electrical engineer registered in the State of Arizona certifies that the electrical equipment does not pose any hazard to public health or safety when inundated;
    a. Improvement Plans must show the location of electrical equipment, the design elevation and the 100-year water surface elevation, and;
    b. A Registered Electrical Contractor must certify that all electrical installations meet all standards for placement in or near ponded water.

2. One or more signs are required for basins designed with human activity zones to inform the public of the basin purpose and potential hazard resulting from collection of stormwater. Signage must be visible from the activity area, pedestrian access and vehicular access. Signs shall comply with the standards of Section 4.12.

3. When drainage crosses a pedestrian access, scuppers, or other cross drainage structures shall be provided. The cross drainage capacity shall be the 10-year peak discharge at the crossing.

4. A basin designed with human activity zones shall contain a minimum of one pedestrian access slope of 8:1 or flatter and a maximum of 100 feet either to the base of an access slope or to a 4:1 or flatter basin side slope.

5. All facilities and furnishings placed below the elevation of the 100-year water surface shall be waterproof and not floatable.

6.1.2 Maintenance Requirements

1. All applicable maintenance requirements from Chapter 4, Detention Basin Design Standards, shall be met.

2. All equipment, hardscape, furnishings, electrical equipment shall be maintained to the original design standards.

3. Inspections shall occur after storm events. If damage to materials or furnishings is apparent, the basin configuration shall be restored to the original design configuration.

6.1.3 Prohibitions

1. 100-year water depths greater than 3 feet are prohibited.

2. Electrical equipment without certified waterproofing below the 100-year water depth is prohibited.

3. Hardscape, seating and tables, sports equipment and any other materials which float or are not waterproof are prohibited.

4. Obstruction of inlets or outlets is prohibited.

6.2 Basins Containing Landscape Buffer Yards

6.2.1 General Requirements

1. When landscape buffer yards are required by the Pima County Zoning Code, Chapter 18.72, and detention containing a landscape buffer yard is proposed, an engineering analysis of the detention requirements met by the buffer yards is required as part of the project drainage report.

2. The drainage report must demonstrate that the multiple-uses of buffer yards for both landscaping and detention are compatible.

3. The project landscape plan must be submitted to the District for review prior to final approval of the Development Plan or Final Plat.

4. The District will review for requirements of the Floodplain Ordinance. Landscape requirements shall be reviewed by the Development Services Department.

5. All applicable requirements of Chapter 4, Detention Basin Design Standards, and Chapter 5, LID Practices Design Standards shall be met.

6.2.2 Landscape Buffer Yards Maintenance Requirements

1. All applicable maintenance requirements from Chapter 4, Detention Basin Design Standards, shall be met.

6.2.3 Landscape Buffer Yards General Prohibitions

1. Landscaping shall not obstruct flow conveyance, inlets or outlets.

7 Covenants

7.1 General Requirements

1. The District requires covenants to be recorded with the Pima County Recorder's Office when any of the following stormwater detention practices are proposed:
    a. Low Impact Development Practices,
    b. Embankments,
    c. Underground Storage,
    d. Pumps, and
    e. Dry wells.

    Appendix A contains example covenants and exhibits.

2. Covenants shall comply with the requirements of Chapter 16.38 of the Floodplain and Erosion Hazard Management Ordinance.

3. For corporate covenants, the signer shall provide sufficient documentation to demonstrate authorization to sign for the company. Sufficient documents include:
    a. Articles of Incorporation,
    b. A corporate resolution demonstrating the individual's authority to represent the company, or
    c. A notarized letter on company letterhead that indicates that the person is allowed to represent the company.

4. Covenants shall be recorded prior to approval of the Development Plan or Final Plat, and the Sequence No. shall be provided on the Development Plan or Plat in a General Note on the Cover Sheet of the Plan or Plat.

5. The covenants must specify inspection and maintenance responsibilities of the property owners. It shall be the responsibility of the property owner(s) to perform maintenance as necessary to ensure the integrity of the stormwater detention facilities.

8 Detention Waiver request and Payment of In-Lieu Fee

Sections 16.48.030 and 16.48.040 of the Ordinance allow collection of a fee in lieu of a detention system when certain structural flood control measures are provided or it can be demonstrated that detention at the site does not provide offsite flood relief due to parcel size, location within the drainage basin, or other factors.

8.1 Waiver Request Requirements

1. Waiver requests may be submitted for projects within Balanced Basins. When a project is within a Critical Basin, only projects adjacent to a major watercourse, in accordance with paragraph 2.c. below, are eligible for a waiver.

2. At least one of the following shall be demonstrated when a detention waiver is requested:
    a. Structural flood control measures, conforming to the requirements of Section 16.48.30, are proposed in place of detention systems.
    b. The project site is one acre or less.
    c. The project is located adjacent to a major watercourse. For the purpose of this manual a major watercourse has a 100-year peak discharge of 10,000 cfs or greater. Approval to classify another watercourse as a major watercourse may be granted by the Floodplain Administrator if engineering justification demonstrates adequate downstream capacity within the watercourse to convey the 100-year flood peak to a logical downstream conclusion under conditions of ultimate watershed urbanization.
    d. The project is located on a secondary tributary of a primary tributary, draining a watershed of no more than 10 square miles, of a major watercourse and the relationship between the travel time of the discharge from the project and the rise times of the hydrographs of the project flows and the primary tributary meet the satisfy Equation 8.1; it can be demonstrated that the natural watercourses and drainage infrastructure within the secondary tributary watershed have adequate capacity to convey the future 100-year flood peak emanating from the watershed under conditions of ultimate watershed urbanization; it can be demonstrated that the primary tributary peak discharge is not affected by the future 100-year flood peak from the secondary tributary or, if it is affected, the primary tributary and all drainage infrastructure downstream of the confluence of the secondary and primary tributaries have adequate capacity to convey the future 100-year flood peak under conditions of ultimate watershed urbanization.
    e. The development has a density that is less than 2 units to the acre and preserves natural drainage patterns. The development shall not rely on constructed drainage facilities, such as constructed channels and storm drains to convey stormwater runoff, or

f. The project site is eligible for a waiver due to other engineering justification acceptable to the District.

3. Demonstration of the criteria in this section does not guarantee approval of a detention waiver request.

8.1.1 Tributary Location

1. If the project site is located on a secondary tributary of the major watercourse (e. g., Channel 2 of Figure 8.1) then it must be demonstrated that the secondary tributary and all drainage infrastructure within the sub-watershed have adequate capacity to convey the future 100-year flood peak emanating from that portion of the sub-watershed which contains not only the proposed development, but also all areas upstream of the development. For instance, segment BC of Channel 2 in Figure 8.1and any associated drainage infrastructure must have adequate capacity to convey the 100-year flood peak emanating from the areas draining into Channel 2 upstream of Point C, based upon conditions of ultimate watershed urbanization. In this example, if Equation 8.1 is met, it would not be required to demonstrate that segment AB of Channel 1 and associated drainage infrastructure have adequate capacity, since flood peaks would not be increase on this primary tributary as a result of the proposed development.

2. Peak discharges and times of concentration used in this analysis shall be calculated by the Pima County Hydrology method. Hydrograph rise times shall be calculated by the methods presented in Appendix K.

$$Equation\ 8.1 \qquad \frac{T + T_r'}{T_r''} \leq 0.40$$

Where

T = 100-year flow travel time between the downstream point of the project site and the confluence with a major watercourse, as defined in 8.1, paragraph 1.c. T shall be calculated by the incremental time of concentration illustrated in Example 8.1 below.

T_r' = Rise time of the 100-year synthetic flood hydrograph for on-site drainage emanaging from the project site under developed conditions

T_r'' = Rise time of the 100-year synthetic flood hydrograph at its confluence with the major watercourse for drainage emanating from the entire watershed. T_t'' shall be determined using the assumption that the entire water shed is fully developed with no stormwater detention facilities.

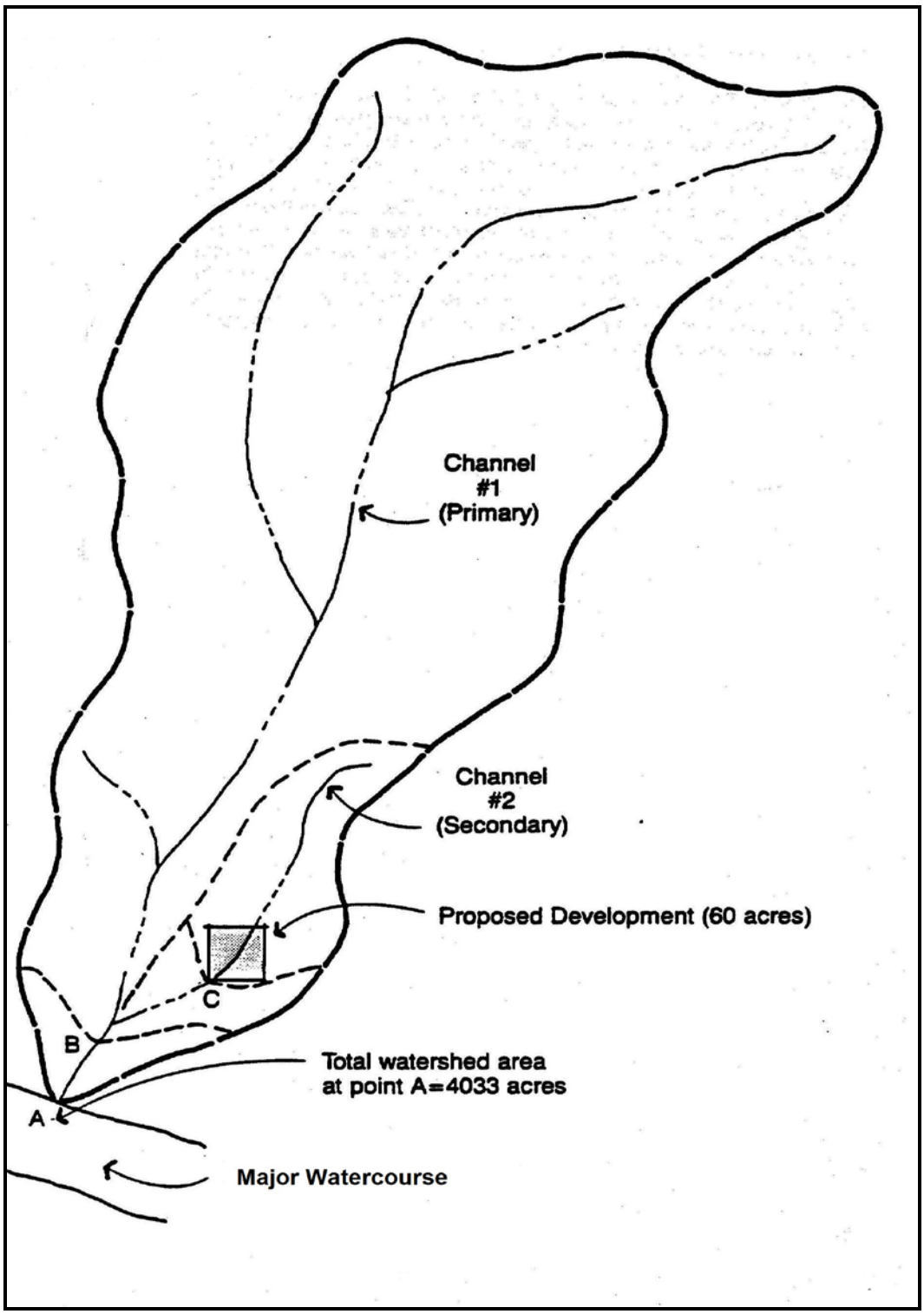


Figure 8.1. Sample Watershed for Example 8.1
(Stormwater Detention/Retention Manual, Pima County Department of Transportation and Flood Control District, City of Tucson)

Example 8.1

A 60-acre parcel proposed for high-density urban development, is located in the extreme lower portion of a 4033-acre sub-watershed of the Rillito Creek. The watershed locations are illustrated in Figure 8.1

The purpose of the example is to illustrate the method for deterimining if it can be demonstrated that the project is eligible for a detention waiver under the requirements of Section 8.1, paragraph 1.d.

Times of concentration, determined by PC-Hydro, for points along the channels of interest are:

Channel 1, Point A t_c = 61 minutes
Channel 1, Point B t_c = 57 minutes

Channel 2, Point B t_c = 25 minutes
Channel 2, Point C t_c = 17 minutes

The travel time through the reach of Channel 1 between Points A and B,

T_{AB} = 61 minutes – 57 minutes = 4 minutes

The travel time through the reach of Channel 1 between Points B and C,

T_{BC} = 25 minutes – 17 minutes = 8 minutes

The total travel time $T = T_{AB} + T_{BC}$ = 4 minutes + 8 minutes = 12 minutes

Incremental travel times are calculated for each channel segment located between the major watercourse and the project site. The total travel time, T, is the sum of the incremental travel times.

Determine T_r':

The time of concentration for the on-site developed conditions runoff from the 60-acre parcel is obtained from PC-Hydro and is 6 minutes. The rise time, T_r', obtained from the table in Appendix K is 14 minutes.

Determine T_r'':

For Channel 1, Point A, the time of concentration is 61 minutes. T_r'' = 53 minutes is calculated by Equation K.1 in Appendix K.

From these values, Equation 8.1 is evaluated:

$$\frac{T + T_r'}{T_r''} = \frac{12 + 14}{53} = 0.49$$

The value of the solution is 0.49 which is greater than the limiting value of 0.40; therefore it has not been demonstrated that the location of the project site relative to the primary tributary meets the criterion for a waiver stated in Section 8.1, 1.d. Furthermore, even if the solution is less than the limiting value, downstream channel and drainage infrastructure adequate capacity must also be demonstrated.

8.2 Waiver Application Requirements

8.2.1 Waiver Request Form

1. To apply for a waiver, the owner or owner's representative shall obtain a Detention Waiver Request Form from http://rfcd.pima.gov/pdd/guidelines/pdfs/det_waiver.pdf, complete all sections and submit directly to the District. A copy of the fee calculation sheet is available at this link for planning purposes. The fee required shall be calculated by the District after a review of the request.

8.2.2 Waiver Request Submittal Procedure

1. The Request Form and Attachments shall be submitted to the Division Manager of the Planning and Development Division of the District.

2. The submittal should be made as early in the site planning process as possible.

3. The submittal shall be a stand-alone document, separate from any Drainage Report prepared for the project.

8.2.3 Waiver Request Attachments

1. The following attachments must be provided with the waiver request:
    a. An exhibit, to scale, with the following information;
        i. The project boundaries,
        ii. Adjacent major streets,
        iii. Nearby watercourses, if applicable,

iv. The location of existing and developed conditions concentration points with 100-year peak discharges,
v. Proposed LID practices and
vi. If proposed, structural flood control measures.

An example is provided with the waiver request form and found at: http://rfcd.pima.gov/district/forms.htm.

b. Aerial photo with the project area outlined, showing surrounding adjacent properties,
c. PC-Hydro output data sheets for on-site existing and developed conditions concentration points and for concentration points where flows exit the project,
d. PC-Hydro output data sheets for the entire site area; one data sheet with a basin factor for existing conditions and one data sheet with a basin factor for developed conditions,
e. The estimated required detention volume calculated from Equation 3.7.
f. Other supporting engineering justification, such as solution to Equation 8.1, capacity calculations for downstream tributaries and drainage infrastructure, and other applicable supporting documentation.

8.2.4 Waiver Request Response and Approval

1. The District will provide a response letter to the Applicant within 10 working days following the waiver request submittal.

2. If the request is approved, a fee calculation sheet with the required fee will be provided with the response letter.

3. If the request is approved, the applicant shall provide an electronic copy of the District-approved application and all the attachments outlined in Section 8.2.3 prior to approval of the Development Plan or Final Plat.

4. A copy of the District's response letter granting approval of the waiver request shall be provided in the Drainage Report.

5. The fee shall be paid to the District, according to the instructions in the response letter, prior to final approval of the Development Plan or Final Plat.

6. If the waiver request is denied for incompleteness, the Applicant shall provide additional information as requested in the response letter and re-submit the waiver request for an additional review.

7. If the waiver request is denied because the project does not meet any of the criteria found in Section 8.1.1, detention must be provided.

9 DRAINAGE REPORT CONTENT

The drainage report shall contain a separate section entitled Stormwater Detention and Retention. This section shall contain sufficient analyses and information to demonstrate that the applicable requirements of this manual will be met for the project.

9.1 Content for an Approved Detention Waiver

1. If a waiver has been approved by the District, the Stormwater Detention Section shall contain the following:
    a. A short discussion of the justification for the waiver.
    b. Copy of the Detention Waiver approval letter.

9.2 Content for Lid Practices

1. Provide a description of stormwater harvesting basins used and the analysis that meets the first-flush retention requirement using the methodology found in Section 2.2.

2. Provide a discussion of use of additional LID practices, including:
    a. Minimized disturbed and impervious surfaces,
    b. Protection/enhancement of riparian habitat and regulatory floodplains and other high permeability areas, such as natural areas ,
    c. Disconnected impervious surfaces,
    d. Lengthened flow paths.
    e. Use of conveyance systems which mimic natural conditions, and
    f. Decentralization of detention basins

3. When stormwater harvesting basins are proposed, provide the analysis for the peak discharge rate reduction for each return period using the methodology presented in Section 3.3.

4. Provide a stormwater harvesting basin summary table which uses the same basin labels as shown on the proposed conditions drainage exhibit and the project plan with the following:
    a. First-flush Retention volume, if applicable (cubic feet or acre feet)
    b. Bottom elevation (feet),
    c. Invert elevations for inlet and overflow (feet), if applicable,
    d. Dimensions of inlets and overflow, if applicable,
    e. Stormwater harvesting basin retention volume (cubic feet or acre feet),
    f. The contributing area to each basin or group of basins (square feet or acres)
    g. The reduced peak discharge rates for all return periods as a result of the basins.

5. Provide a cross-section of each stormwater harvesting basin showing and labeling the following information, as applicable. Examples can be found in Chapter 5 of each different type of basin:
    a. Side slope with surface treatment and the horizontal-to-vertical ratio indicated,
    b. 100-year water surface elevation,
    c. If applicable, inlet and overflow structures with dimensions, material type and elevations specified, and
    d. Inlet and overflow protection, toe down, rock riprap (length, thickness, treatment, rock size).

6. Provide a cross-section of each bioretention basin, showing and labeling material layers and surface depression and side slopes.

7. On the Proposed Conditions Drainage Exhibit, show the location of all LID practices.

9.3 Content for Detention Basins

1. A brief summary of the applicable detention requirements relevant to the development including a statement about the project's location within a Balanced or Critical Basin.

2. A description of the detention proposed to achieve the required post-development peak discharge or runoff volume reduction for the project.

3. Stage-storage-discharge table.

4. A description of inlet and outlet structures, with supporting design calculations, including:
    a. Hydraulic calculations for all inlet and outlet structures
    b. Calculations for erosion protection dimensions and rock sizing, and
    c. Calculations demonstrating that flows exiting the project boundary approximate flow characteristics of pre-developed conditions.

5. The analysis of the storage-indication method to determine amount of peak discharge rate reduction by a basin along with supporting documentation shall be provided. The following storage-indication methods can be used to determine the reduction peak discharge rate:
    a. The District's PC-Route.xls spreadsheet.
        i. Supporting documentation for this method shall include:
            1. Worksheets from the RFCD Basin Routing spreadsheet.
    b. HEC-HMS Version 3.3, or higher.
        i. Supporting documentation for this method shall include:
            1. HEC-HMS model summary output, and
            2. A CD of the modeling.

6. A basin summary table with the following basin design parameters:
    a. Detention Volume (cubic feet or acre feet)
    b. Retention depth and volume (if applicable)
    c. Top and bottom elevations (feet) ,
    d. 100-year water surface elevations(feet),
    e. Invert elevations for inlets and outlets feet),
    f. Dimensions of inlets and outlets,
    g. 2-, 10- and 100-year inflows (cubic feet per second), and
    h. 2-, 10- and 100-year outflows (cubic feet per second).

7. A cross-section of the basin showing and labeling the following information as applicable:
    a. Bottom slope (0.5% minimum unless retention is provided)
    b. Side slope with surface treatment and the horizontal-to-vertical ratio indicated,
    c. 100-year water surface elevation,
    d. Inlet and outlet structures with dimensions, material type and elevations specified
    e. Outlet protection, toe down, rock riprap (length, thickness, treatment, rock size),
    f. Impervious interior surface treatment shall be specified when embankment conditions impounding more than 1 foot of water are proposed, and
    g. Security barrier

8. Cross-sections perpendicular and parallel to the basin inlet and outlet structures.

9. When a basin is located to accept flows from predominantly natural areas, supporting calculations for sediment basin design shall be provided by an engineer registered in the State of Arizona.

10. When a basin is proposed less than 15 feet away from a structure, the recommended minimum separation between a basin and a structure shall be provided by a geotechnical engineer registered in the State of Arizona.

11. When an embankment is proposed, the following shall be provided:
    a. Justification for the use of the embankment(s),
    b. For embankments designed to impound greater than 1 foot of water, the calculations for the emergency spillway design capacity as outlined in Section 4.10.1.6.,
    c. Engineering analysis for erosion protection if the embankment is located within an erosion hazard setback or regulatory sheet flood area, and
    d. A copy of the covenant to be recorded. The covenant shall be recorded prior to approval of the project.

12. When an underground storage system is proposed the following shall be provided:
    a. Justification for the use of underground storage,

b. A storage volume analysis documenting 1.5 times the design volume of an above ground basin,
c. The drainage path to deliver flows in a reasonable and safe manner in the event the system cannot accept flow,
d. A copy of the covenant to be recorded, and
e. A copy of the report specified in Section 4.14.1.8.

13. When a pump is proposed, the following shall be provided:
    a. Justification for the use of the pump,
    b. The District's written acceptance to use the pump,
    c. Analysis demonstrating that the pump can accommodate the entire volume of the 100-year post-developed hydrograph emanating from the contributing drainage area or a statement will be included indicating that a back-up pump with an emergency power source will be utilized,
    d. Demonstration that the pump's discharge rate does not exceed the pre-developed conditions 2-year peak discharge rate,
    e. Trash rack/screen design calculations using a 2.0 clogging factor,
    f. Emergency back-up plan,
    g. Drainage exhibit showing drainage flow under clogged conditions,
    h. Maintenance Plan with, at minimum, the following:
        i. Maintenance schedule,
        ii. Type of maintenance activities, and
        iii. Exhibit showing the location of the pump, alarm systems and other equipment,
    i. A copy of the covenant to be recorded, The covenant shall recorded prior to authorization of the project, and
    j. A copy of the pump system analysis as outlined in Section 4.19.1.16.

9.4 Content For Dry Wells

1. When a dry well is used as a method of disposal, the following shall be provided:
    a. Justification for the use of a dry well,
    b. The District's written approval/acceptance of the dry well,
    c. A copy of the percolation test that determines the stabilized infiltration rate,
    d. Drywell system design by a licensed professional,
    e. Calculations and supporting documentation for the drywell disposal rate,
    f. Dry well specifications and cross-section of a typical well,
    g. Depth to groundwater information,
    h. Documentation that the disposal rate meets the storage time standards found in Section 4.5,
    i. A plan for stormwater disposal in the event the drywell(s) cease(s) to function,
    j. Maintenance Plan with at minimum the following:
        i. Maintenance schedule,
        ii. Type of maintenance activities,

iii. Exhibit showing the location(s) of the drywell(s), and
iv. Contact information of the driller or authorized maintenance professional, and

k. A copy of the covenant to be recorded. The covenant shall recorded prior to authorization of the project.
l.

9.5 Required Summary Table For All Projects

1. A table of the 2-, 10- and 100-year peak discharges for pre-developed, post-developed without detention and post-developed with detention at all concentration points where flows exit the project site.
    a. The table shall demonstrate that the post-developed with detention peak discharges do not exceed the pre-developed peak discharges or are reduced, as required.
    b. If developed conditions watersheds have a different configuration than pre-developed conditions watersheds, the table shall correlate the developed concentration points with the pre-developed concentration points. The location of post-developed concentration points at the downstream property boundary must approximate the location of the pre-developed concentration points at the downstream property boundary.

10 REQUIREMENTS FOR PLATS AND DEVELOPMENT PLANS

The following information shall be placed on or submitted with plats and development plans.

10.1 Required Detention Basin Content for Tentative Plats And Development Plans

10.1.1 Detention Waiver

1. If a Detention Waiver has been granted for the project, provide a General Note:

   "A Waiver Of Detention Requirements Has Been Granted For This Project By The Regional Flood Control District. The Owner Has Paid A Fee In Lieu Of Providing Stormwater Detention Facilities."

10.1.2 General and Permitting Notes

1. If Detention is provided, provide the following General Note, with the relevant volumes. If detention is not provided by a certain practice, enter zero cubic feet for that practice:

   "This project is required to provide Stormwater Detention. The total volume of detention provided is _____ cubic feet.

   The total volume is provided by the following practices:

Below Grade Excavated Basin(s	_____	*cubic feet*
Engineered Basin Side	_____	*cubic feet*
Stormwater Harvesting Basin(s)	_____	*cubic feet*
Underground Storage	_____	*cubic feet*

2. When a project includes LID practices, embankments, an underground storage system, pumps or a dry well, provide the following General Note:

   "This Project Includes _____ [LID Practices, Embankments, Underground Storage System, Pumps Or Dry Well(s)]. An Inspection and Maintenance Plan Has Been Provided to the Homeowner's Or Property Owner's Association. An Inspection And Maintenance Covenant Has Been Recorded At Sequence No. _____, Of The Public Records Of Pima County."

   Provide the recording information prior to Tentative Plat or Development Plan approval.

3. When a project has drainage and grading improvements that are required to mitigate off-site adverse impacts the proposed development an as-built plan shall be prepared

and submitted to the District. The as-built plans require District approval prior to the issuance of any building permits, except for model home permits and any permits necessary to build drainage infrastructure.

Provide the following Permitting Note for Development Plans and General Note for Tentative Plats to disclose this requirement:

> *"Prior To Issuance Of Any Building Permits Pursuant To Section 16.36.030.D. Of The Floodplain Ordinance, An As-Built Plan Of The Drainage And Grading Improvements That Are Required To Mitigate Off-Site Adverse Impacts Shall Be Prepared And Submitted To The District. Upon Approval Of The As-Built Plan By The District, The Hold To Issuance Of Building Permits Can Be Removed."*

10.1.3 Requirements for Detention Basins and Stormwater Harvesting Basins

1. Provide a descriptor box adjacent to the basin. Include a leader arrow to the basin or provide a label for the basin and reference the label on the top of the descriptor box. Include the following applicable information in the descriptor box:
    a. Detention volume (cubic or acre feet),
    b. Q_{100} in (cubic feet per second), if applicable,
    c. Q_{100} out (cubic feet per second), if applicable,
    d. Basin top elevation (feet),
    e. 100-year water surface elevation (feet), and
    f. 100-year ponding depth (feet) (measured from the lowest elevation of the basin).

2. For Tentative Plats, the basin(s) shall be shown within Common Area, and the plat shall indicate in the title block that the Common Area includes drainage.

3. Label the basin as a Private Detention or Stormwater Harvesting Basin.

4. In plan view, show conceptual grading for the basin(s) and include the following information,

    For detention and stormwater harvesting basins include:
    a. Maintenance access,
    b. Location of maintenance ramp (10-foot minimum), if applicable,
    c. Location of sign(s), if applicable,
    d. Conceptual grade contours,
    e. Side-slope horizontal-to-vertical ratio with slope treatment, and
    f. For drainage infrastructure requiring a covenant, provide the Sequence Number adjacent to the applicable structure and/or basin.

g. Location and dimensions of outlet or slope protection. Call out rock size, type of placement or other material.

For detention basins only include:

h. Location of the sediment level device,
i. Security barriers, if applicable, with height (minimum of 42 inches high) and material type indicated,
j. If no retention is proposed within the detention basin, positive drainage to the outlet structure, minimum 0.5% slope, and
k. Location of inlet and outlet structures with inverts or other inlet and outlet elevations. Call out dimensions and materials. Call out the Q_{100} for all structures

5. On a detail sheet, show a cross-section of the basin, with the following information:

For detention and stormwater harvesting basins include:

a. Dimensions of top and bottom areas (feet),
b. Top and bottom elevation (feet),
c. Freeboard elevation (feet),
d. 100-year water surface elevation (feet),
e. Side-slope horizontal-to-vertical ratio with slope treatment,
f. Setbacks from property boundaries (10 foot minimum),
g. Weir or other outlet structure elevation(s) (feet),

For detention basins only include:

h. Security barriers, if applicable, with material type and height, and
i. For embankment conditions indicate the following:
    i. Freeboard elevation (feet) (1 foot minimum),
    ii. 95% compaction, and
    iii. For embankments designed to impound more than 1 foot of water, the following shall be included,
        1. Emergency spillway location, and
        2. Impervious treatment with toe down (minimum depth of 18 inches).

Typical cross-sections are provided in Appendix B.

6. On a detail sheet, show cross-sections perpendicular and parallel to the inlet and/or outlet structures with the following information:
    a. Dimensions (inches or feet),
    b. Material type,
    c. Invert elevations (feet), and
    d. 100-year peak discharge (cubic feet per second).

A typical detail is provided in Appendix B.

7. On a detail sheet, show dimensions, rock sizing, fabric filter placement, and/or cutoff walls for any proposed erosion protection. The erosion protection shall be shown extended below finished grade.

8. When a retaining wall is utilized as a basin side, a preliminary structural design detail for the retaining wall must be provided. The preliminary design shall include at a minimum the wall and footing dimensions. The intent is to demonstrate that the foundation of the wall will not negatively impact property setbacks or easements and to provide assurance that soil saturation has been considered. The detail shall be provided on one of the detail sheets for the project, may be marked preliminary and should be attributed to the design engineer, if the design engineer is different from the project engineer. Complete structural design and construction drawings will be submitted as required by Development Services during the construction permitting process.

9. When an underground storage system is proposed, prior to approval of the Tentative Plat or Development Plan, a report from an engineer registered in the State of Arizona shall be provided that contains at least the following:
    a. Appropriate building setbacks from the underground storage system related to structural integrity,
    b. Certification that the load bearing capacity of the soils underlying the underground storage structure is adequate and the soil complex is appropriate bed material,
    c. Structural design details, and
    d. Other design recommendations if appropriate.

10. When a pump is proposed as a method of disposal, the following applies:
    a. District approval to use the pump is required prior to the first submittal of the Tentative Plat or Development Plan.
    b. If the District allows the use of a pump, a pump system analysis shall be provided with the first review submittal. The analysis shall include the information outlined in Section 4.19.
    c. When the project includes a pump(s), the following information shall be included on the plan view:
        i. Location of the service equipment, and
        ii. Location of the sump with dimensions shown.

11. When a dry well is used as a method of disposal, the following apply:
    a. District approval to use a dry well is required prior to the first review submittal. When requesting the approval, the engineer must submit the field investigation results and a preliminary site plan as outlined in Section 4.20,
    b. When the project includes a drywell(s), the following information shall be included on the plan view:
        i. A detail showing the typical dry well installation,

ii. A detail showing the words "Stormwater Only" stamped in raised letters on the drywell grate, and
iii. On the plan view the location of the drywell(s).

10.1.4 Requirements for LID Practices other than Stormwater Harvesting Basins

1. When Non-Contributing Area Basins or Bio-Retention Basins are proposed, the following apply:
   a. When the project includes a non-contributing area basin(s) or bio-retention basin(s), the location of the basin(s) shall be called out on the plan view.
   b. On a detail sheet, cross-sections perpendicular and parallel to the basin(s) shall be provided.

10.2 Required Detention Basin Content For Final Plats

10.2.1 Detention Waiver

1. If a Detention Waiver has been granted for the project, provide a General Note:

   "*A Waiver Of Detention Requirements Has Been Granted For This Project By The Regional Flood Control District. The Owner Has Paid A Fee In Lieu Of Providing StormWater Detention Facilities."*

10.2.2 General and Permitting Notes

1. If detention is provided, provide the following General Note, with the relevant volumes. If detention is not provided by a certain practice, enter zero cubic feet for that practice:

   "This project is required to provide Stormwater Detention. The total volume of detention provided is _____ cubic feet.

   The total volume is provided by the following practices:

Below Grade Excavated Basin(s)	_____	*cubic feet*
Engineered Basin Side	_____	*cubic feet*
Stormwater Harvesting Basin(s)	_____	*cubic feet*
Underground Storage	_____	*cubic feet*

2. If applicable, provide the General Note:

   "This Project Includes _____ [LID Practices, Embankments, Underground Storage System, Pumps Or Dry Well(s)]. An Inspection And Maintenance Plan Has Been Provided To The Homeowner's Or Property Owner's Association. An Inspection And Maintenance Covenant Has Been

Recorded At Sequence No. _____, Of The Public Records Of Pima County."

3. Provide the Permitting Note:

"Prior To The Final Release of Assurances Pursuant To Section 16.36.030.E. Of The Floodplain Ordinance, An As-Built Plan Of The Drainage And Grading Improvements That Are Required To Mitigate Off-Site Adverse Impacts Shall Be Prepared And Submitted To The District. Upon Approval Of The As-Built Plan By The District, The Hold To The Release of Assurances Can Be Removed."

10.2.3 Requirements for Detention Basins and Stormwater Harvesting Basins

1. Show the areas where basins are located as Common Area, and indicate in the title block that the Common Area is intended for drainage.

11 REQUIRED CONTENT FOR AS-BUILT CERTIFICATION AND PLANS

11.1 General Requirements

1. Drainage and grading improvements that mitigate for offsite impacts shall be inspected by a Professional Engineer registered in the State of Arizona. The Engineer shall certify that the improvements were built in conformance to the approved plans. The District's As-Built Certification Document shall be used as the certification. The document is available at: http://rfcd.pima.gov/district/forms.htm

2. When the drainage and grading improvements are built per the approved plan set, the certification document may be submitted without plan sheet attachments.

3. When the drainage and grading improvements are not built to the approved plan, an as-built plan shall be submitted to the District for review and approval along with the certification document. The as-built plan may be the original plan sheets with exceptions noted on the plan or new plan sheets. The submitted plan sheets shall be stamped or labeled As-Built and signed and sealed by the certifying Engineer.

11.1.1 Detention Basins

1. The following, at minimum, shall be certified;
    a. Dimensions at top of slope and at bottom of slope(feet),
    b. Top and bottom elevation (feet),
    c. Freeboard elevation (feet),
    d. Side-slope horizontal-to-vertical ratio,
    e. Setbacks from property boundaries,
    f. Maintenance access (10 foot minimum),
    g. 0.5% slope along basin bottom for positive drainage to the outlet structure when retention is not provided within the detention basin,
    h. Weir or other outlet structure elevation(s) (feet),
    i. Erosion protection, including rock sizing and dimensions,
    j. Cut off wall elevations, if applicable,
    k. When the basin includes embankment conditions, the following;
        i. Freeboard elevation (feet) (1 foot minimum),
        ii. Toe down dimensions,
        iii. 95% compaction, and
        iv. Embankments designed to impound more than 1 foot of water; emergency spillway and impervious treatment with toe down.
    l. When the basin includes a retaining wall, the following:
        i. Dimensions,
        ii. Structural design details,
    m. For underground storage, the following;

i. Building setbacks,
ii. Structural design details,

n. When the basin includes a pump;
   i. Pump sump dimensions, and
   ii. Pump specifications
o. Maintenance ramp, if applicable,
p. Sign(s),
q. Slope treatment,
r. Sediment level device,
s. Security barriers, if applicable,
t. When a project includes a dry well;
   i. Drywell grate with the words "Stormwater Only,"
   ii. Drywell specifications and location(s).
   iii. Verification of ADEQ drywell registration.

11.1.2 Stormwater Harvesting Basins

1. The following at minimum, shall be certified;
   a. Location as proposed,
   b. Dimensions of top and bottom areas (feet),
   c. Top and bottom elevation (feet),
   d. Side slope ratio,
   e. Setbacks (feet),
   f. Maintenance access,
   g. Slope treatment.

2. When bioretention basins are used, the following shall be certified
   a. Depth (inches or feet),
   b. Top dimensions,
   c. Location of the sediment trap,
   d. Vertical inspection pipe,
   e. Material type, and
   f. Soil matrix.

11.1.3 Other LID Practices

1. The following, at minimum, shall be certified;
   a. Location of LID Practice(s),
   b. If disconnection of impervious surfaces is being claimed as a LID practice, construction as designed,
   c. If lengthened flow paths are incorporated as a LID practice, site layout as designed, dimensions of swale and surface treatment of swale.

12 GLOSSARY OF TERMS

Adverse Impact – A change in flow conditions as a result of a development that creates a violation of the Floodplain Ordinance, a safety issue or property damage.

Approval – Written notice by the District approving a submittal including Development Plans; Plats; Drainage Reports; waivers; proposed pumps, drywells, or underground stormwater storage; requests to provide designs, analyses or reporting which is different from the requirements stated in this manual

Approved Plan – The most current Development Plan or Plat which bears the authorized signature of approval.

Arizona Department of Water Resources (ADWR) - The state agency assigned with oversight of flood control as provided in Title 48 Chapter 21 of the A.R.S.

Attenuation – The collective effect of peak discharge or volume reductions achieved by routing flood waters through a detention basin or approved Low Impact Development Practices.

Balanced Basins – A drainage basin or watershed which contains flood water channels, natural or manmade, and/or flood control structures that are adequate to contain existing runoff from the base flood produced by the basin or watershed, but in which additional runoff may not be safely contained by said channels or structures. All drainage basins shall be considered to be balanced basins unless a basin has been designated as a critical drainage basin.

Base Flood – A flood with a one-percent probability of being equaled or exceeded in any given year. Commonly referred to as the 100-year flood, this flood shall be determined from an analysis of floods on a particular watercourse and other watercourses in the same general region in accordance with the criteria established by the director of the ADWR, or the Flood Control District Board, which criterion is hereby incorporated by reference and made a part of this title.

Concentration Point – A hydrologic term which describes any specific point within a watershed here the surface drainage is to be analyzed.

Covenant – Written agreements that impose responsibilities on the land owners and restrictions upon the use of land.

Critical Basin – A drainage basin or watershed that contains flood water channels, natural or manmade, and/or flood control structures that cannot convey existing runoff during a base flood produced by the basin or watershed, and which has a documented history of severe hazards.

Dams – The Arizona Department of Water Resources (ADWR), Surface Water Division, has legal jurisdiction over all dams which exceed certain height and storage limits.

Arizona State Statutes, article 45-1201., defines a dam as any artificial barrier, including appurtenant works for the impounding or diversion of water, twenty-five feet or more in height or the storage capacity of which will be more than fifty acre-feet but does not include:

- Any barrier that is or will be less than six feet in height, regardless of storage capacity.
- Any barrier that has or will have a storage capacity of fifteen acre-feet or less, regardless of height.
- Any barrier for the purpose of controlling liquid-borne material.
- Any barrier that is a release-contained barrier.
- Any barrier that is owned, controlled, operated, maintained or managed by the United States government or its agents or instrumentalities if a safety program that is at least as stringent as the state safety program applies and is enforced against the agent or instrumentality.

Detention Basin – A type of flood control system that delays the downstream progress of flood waters in a controlled manner, generally through the combined use of a temporary storage area and a metered outlet device, which causes a lengthening of the duration of flow and thereby reduces downstream flood peaks.

Development – Any manmade change to improved or unimproved real estate, including, but not limited to, buildings or other structures, mining, dredging, filling, grading, paving, fencing, excavating or drilling or storage of equipment or materials.

Development Plan – An engineering document which shows the site layout for a proposed project overlaid on a map of the site and the surrounding area. The plan shows the proposed building locations and footprints, parking lot layout, access, drainage facilities and utilities for conformance review with applicable regulations.

Disposal Time – The time period during which standing water must be eliminated from a detention basin or Low Impact Development Practices.

District – The County Flood Control District, as established by Title 48, Chapter 21 of the A.R.S., which is named in Pima County as the Pima County Regional Flood Control District.

Disturbance – The condition of land areas that have been damaged, demolished or eliminated.
Drainage Area – The upstream contributing watershed area measured at a single point of drainage concentration and is expressed in units of area. Other terms for this are catchment area, watershed, and river basin.

Drainage Report – A report that provides a description of existing and future site conditions supporting hydraulic and hydrologic data, a delineation of the flood prone areas, and a detailed description of the proposed manner in which drainage shall be handled.

Dry Well – A deep hole covered and designed in such a manner so as to hold stormwater runoff until it infiltrates into the ground.

Embankment – Compacted earth which impounds water.

Emergency Spillway – An outflow spillway from a detention basin which is provided to allow for the safe overflow of floodwaters.

Engineered Basin Side – A detention basin side which is other than an earthen slope constructed below natural grade. Engineered basin sides include above-grade embankments and retaining walls.

Erosion – The physical process where flowing flood water removes sediment and earthen material causing land to wear away and degrade over time.

Filter Fabric – Fabric, typically non-woven, used for soil stabilization to prevent soil shifts and movements in excavated areas.

Final Plat – A survey document suitable for recordation of all or part of a subdivision conforming to an approved Tentative Plat.

First-flush – The delivery of a highly concentrated pollutant loading during the early stages of a storm due to the washing effect of runoff on pollutants that have accumulated on drainage surfaces.

Flood Control – The control of flood waters by employing methods of containment such as a detention system that stops and slows down the downstream progress of flood waters.

Floodplain – Any areas within a watercourse which have been or may be covered partially or wholly by flood waters from the base flood including land that has been, or may be, subject to flooding from stormwater runoff, overflow of flood waters from a watercourse, alluvial fans, sheet flood zones, or other property subject to flooding. The floodplain includes the stream channel, the floodway, and the floodway fringe area.

Freeboard – The distance measured from the top of an impoundment to the 100-year water surface elevation.

Finished Grade – Any ground elevation which has been cut to or built to the design elevation.

Hard Durable Stones – Stones highly resistant to deterioration by natural processes.

HEC-HMS – Hydrologic Modeling System (HEC-HMS) designed to simulate the precipitation-runoff processes of dendritic drainage basins.

Human Activity Zones – Areas used within a basin for multiple purposes other than detention where human recreational activities are involved.

Hydrograph – A graph showing changes over time in the stormwater runoff from a drainage area.

Hydroseed – A mixture of seed, mulch and soil ameliorants applied by spraying or other mechanical means.

Impervious – Not allowing entrance or passage by water.

Impervious Treatment – A process that renders a surface impervious to water.

Inflow – Runoff which flows into a stormwater storage facility from the upstream watershed.

Inlet – Structural element that serves as the entrance of a detention basin where water is directed into the basin.

Inspection – Examination of the conditions of drainage structures to ensure their proper functioning.

Invasive Plants – Plants that invade ecosystems beyond their historical range. Dependent on these ecosystems, invasive plants can threaten native ecosystems or commercial, agricultural, or recreational activities dependent on these ecosystems costing the economy billions of dollars on an annual basis.

Landscape Buffer Yard – A strip of land used for landscaping to separate one type of land use/zoning from another. Landscape buffer yards are a requirement of Pima County Zoning Code, Chapter 18.72.

Length of Watercourse – The length of the flow path taken by water runoff from a surface.

Low Impact Development (LID) – Practices that utilize basic principles modeled after the natural environment by managing runoff and urban water use at the source using small-scale controls uniformly distributed.

Maintenance – The upkeep of drainage structures to assure conformance with approved design and storage volume over time.

Maintenance and Inspection Plan – A plan to upkeep and examine drainage structures over the life of the project.

Major Watercourse – For the purposes of this manual, a natural channel which conveys a 100-year peak discharge of 10,000 cfs or more, or a watercourse which has been designated as a major watercourse for an individual instance based on engineering justification accepted by the Floodplain Administrator.

Multiple-Use Concepts – Concepts employed in an engineered basin which that provide benefits in addition to the primary function of flood control. Such benefits may include recreation, water harvesting, or visual buffers.

PC-Hydro – A semi-empirical rainfall-runoff model accepted in Pima County for predicting flood peaks from ungaged watersheds under natural and developed hydrologic conditions.

Peak Discharge – The maximum flow rate, in terms of volume per time, passing a particular location during a storm event.

Pima County – The incorporated, as well as the unincorporated areas of Pima County, including public lands, but excluding Indian and military reservations and those incorporated areas of cities or towns which have elected to assume separate floodplain management powers and duties pursuant to Section 48-3610 of the Arizona Revised Statutes.

Pre-Developed Conditions – Site conditions related to drainage prior to land development.

Primary Tributary – A channel which flows directly into a major watercourse.

Project Boundary – The boundary that sets the limits of the project site.

Post-Developed Conditions – Site conditions related to drainage after land development.

Positive Drainage – The drainage condition which provides for removal of stormwater from a site within the required disposal time and prevention of ponding of water for periods exceeding the required disposal time.

Outflow – The discharge which exits a stormwater storage facility by means of an outlet structure.

Outlet – The point at which stormwater runoff flows out of an engineered basin. Outlets may consist of culverts, weirs, orifices, or any combination thereof.

Rainwater – Liquid water that has precipitated from atmospheric water vapor but has not yet landed on the earth's surface or any protrusions on the earth's surface.

Recorded – Placed into the public record by the Pima County Recorder.

Regional Detention Basin – A detention basin which collects stormwater runoff from a relatively large area, and has been designed to use storage as a means of reducing downstream flood peaks, reducing possible flood damage, or reducing downstream channel construction costs. Regional facilities are usually multi-purpose, and normally are the responsibility of a public entity.

Riparian Habitat – Riparian habitat designated as riparian on maps adopted by the Pima County Board of Supervisors. These habitats are generally characterized by vegetation that is different in plan species composition or an increase in the size and/or density of vegetation as compared to upland areas occurring in association with any regulatory floodplain and stream channel where waters flow at least periodically in a channel or as dispersed flow, or other features associated with a floodplain such as a spring, cienega, lake, watercourse, river, stream, creek, wash, arroyo or other surface body of water.

Regulatory Floodplain – That portion of the geologic floodplain associated with a watercourse, including its channel, or any other floodplain or floodprone area that would be inundated by the base flood, including all base floods where the base flood peak discharge is 100 cfs or greater, those areas that are subject to sheet flooding except when the maximum potential contributing watershed area is less than 20 acres, those areas identified on subdivision plats or development plans, those areas designated by FEMA, including areas designated as Shaded Zone X as well as those areas that the Chief Engineer, using the best available data, has determined is subject to a flood hazard during the base flood.

Retention – Containment of stormwater by a method which does not allow downstream progress of the stormwater.

Riprap – A rock layer combination of large stone, cobbles and boulders that protects earthen surfaces from erosion.

Routing – A mathematical procedure for predicting the changing magnitude, speed, and shape of a flood wave as it travels through a detention basin.

Runoff – Stormwater flowing over a surface.

Secondary Tributary – A natural channel which discharges into a primary tributary.

Setback – The horizontal distance between an object of interest and perimeter of a basin or property boundary.

Sediment – An earthen material that is carried and deposited by water.

Site – Area where a project is located including improved areas, open space, floodplains and other regulatory development areas.

Storage – Volumetric measurement of the water stored in the detention basin.

Stormwater – Rainwater once it has landed on a surface.

Stormwater Harvesting – The process of intercepting stormwater from a surface such as a roof, parking area, or land surface, and putting it to beneficial use.

Subdivision – Improved or unimproved land or lands divided or proposed to be divided for the purpose of sale, lease, or for cemetery purposes, whether immediate or future, into six or more lots, parcels or fractional interests.

Subsoil – The layer of soil under the topsoil on the surface of the ground.

Sustainability Principles – The development and construction principles that support a sustainable future.

Swale – A ditch or depression that is cut into the soil.

Technical Policy (Policies) – Publications by the District which clarify the permitting requirements of the Pima County Floodplain and Erosion Hazard Management Ordinance.

Tentative Plat – A tentative plat is a map showing the existing conditions of the property and surrounding area on which proposed development is overlaid, which can include topography, infrastructure improvements, and existing structures. It is reviewed for compliance with applicable regulations.

Time of Concentration – The time required for storm runoff to flow from the hydraulically most remote point of a catchment or drainage area to the outlet or point under consideration.

Watershed – The contributing drainage area located upstream of a specific point along a watercourse.

Weir – A structure placed at the basin outlet to control the volume of outflow.

13 REFERENCES

American Society of Civil Engineers, 1998, *Urban Runoff Quality Management*, WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87, by Joint Task Force of the Water Environment Federation and the American Society of Civil Engineers, Larry A. Roesner and Ben R. Urbonas, chmn. (pages 175-178 [approximately the 85th percentile 24-hour storm runoff event]).

Arizona State Revised Statutes, Title 45-Waters, Chapter 6 Dams and Reservoirs, Article 1 Supervision of Dams, Reservoirs and Projects, Section 1201 Definitions.

California Stormwater Quality Association, Stormwater Best Management Practice Handbook: Construction. Available at: http://www.cabmphandbooks.com/Documents/Construction/SE-4.pdf

City of Tucson, Standards Manual for Drainage Design and Floodplain Management in Tucson Arizona. December 1989, revised July 1998.

City of Tucson, Water Harvesting Guidance Manual. October 2005. Available at http://dot.ci.tucson.az.us/stormwater/downloads/2006WaterHarvesting.pdf

Drainage and Channel Design Standards for Local Drainage for Floodplain Management within Pima County, Arizona. June 1, 1984.

Federal Highway Administration, Hydraulic Engineer Circular No. 14; HEC-14, Third Edition. Hydraulic Design of Energy Dissipators for Culvert and Channel. July 2006.

Hydrologic Engineering Center - Hydrologic Modeling System, HEC-HMS, User's Manual, Version 2.1. January 2001.

PC-Hydro V5, Pima County Hydrology Procedures. A Computer Program for Predicting Peak Discharges of Surface Runoff from Small Semi-Arid Watersheds in Pima County, Arizona. PC-Hydro User Guide. March 2007.

Pima County Title 16, Floodplain and Erosion Hazard Management Ordinance. June 3, 2010.

Pima County Regional Flood Control District, Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines. October 2009. Available at: http://www.rfcd.pima.gov/wrd/riparian/pdfs/revised_guidelines_oct2009.pdf

Pima County Regional Flood Control District, Technical Policy, TECH-015, Acceptable Methods for Determining Peak Discharges. October 1, 2007. Available at: http://www.rfcd.pima.gov/rules/.

Pima County Subdivision and Development Street Standards. April 5, 2005.

Pima County/Tucson, City of Stormwater Detention/Retention Manual. February 1987. Available at: http://www.rfcd.pima.gov/rules/pdfs/manual_storm_det_ret.pdf.

Pima County Zoning Code, Chapter 18.73, Landscaping, Buffering and Screening Standards. October 1985.

San Diego, County of, Low Impact Development Handbook: Stormwater Management Strategies. Department of Planning and Land Use, San Diego, California. Available at: http://www.sdcounty.ca.gov/dplu/docs/LID-Handbook.pdf 2007.

Truckee Meadows Low Impact Development Handbook: Guidance on LID Practices for New Development and Redevelopment. Available at: http://www.cityofreno.com/Index.aspx?page=996 2005.

United States Department of Agriculture, Urban Hydrology for Small Watersheds, Technical Release 55, June, 1986.

United States Green Building Council. 2009 (updated November, 2011). *LEED for Neighborhood Development Rating System*. USGBC.org.

Watershed Management Group, *Green Infrastructure for Southwestern Neighborhoods, Version 1.0,* August 2010.

Zeller, M.E., Hydrology Manual for Engineering Design and Floodplain Management within Pima County, Arizona. Pima County Department of Transportation and Flood Control District, September 1979.